COMANDO DA AERONÁUTICA

CENTRO DE INVESTIGAÇÃO E PREVENÇÃO DE ACIDENTES AERONÁUTICOS

FINAL REPORT
A-080/CENIPA/2018

OCCURRENCE:	**ACCIDENT**
AIRCRAFT:	**PR-WBV**
MODEL:	**PC-12**
DATE:	**01MAI2018**

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 considering 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 distinct 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 Final Report has been made available to the ANAC and the DECEA so that the technical-scientific analyses of this investigation can be used as a source of data and information, aiming at identifying hazards and assessing risks, as set forth in the Brazilian Program for Civil Aviation Operational Safety (PSO-BR).

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. Considering 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 01May2018 accident with the PC-12 aircraft, registration PR-WBV. The accident was typified as “[SCF-PP] Engine failure or malfunction | With propeller”.

At the beginning of the descent phase, a failure occurred in the aircraft's propeller pitch-control system, which tended to feather the engine. There was no effective recovery from that condition.

The crew attempted to make a forced landing at SDUB (Ubatuba A/D, State of São Paulo), and crashed in a swampy area near the runway.

The aircraft sustained substantial damage.

The Pilot in Command (PIC) received serious injuries, the pilot Second in Command (SIC) and two passengers suffered minor injuries, while the other six passengers were not hurt.

The following countries designated accredited representatives (*) for participation in the investigation: Switzerland (State of Aircraft Design & Manufacture: *Swiss Transportation Safety Investigation Board - STSB); United States of America (State of Propeller and Modular Avionics Unit Design & Manufacture: *National Transportation Safety Board - NTSB); and Canada (State of Engine Design & Manufacture: *Transportation Safety Board - TSB).

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GLOSSARY OF TECHNICAL TERMS AND ABBREVIATIONS

ACMS	Aircraft Condition and Monitoring System
AFM	Aircraft Flight Manual
AMM	Aircraft Maintenance Manual
ANAC	Brazil's National Civil Aviation Agency
ATC	Air Traffic Control
CA	Airworthiness Certificate
CAS	Crew Alerting System
CIV	Pilot's Flight Logbook
CL	Condition Lever
CMA	Aeronautical Medical Certificate
CRM	Crew Resource Management
CVR	Cockpit Voice Recorder
FCA	Aircraft Coordination Frequency
FDR	Flight Data Recorder
FHDB	Fault History Data Base
FOD	Foreign Object Damage
GPS	Global Positioning System
HMNT	Single Engine Turbine Helicopter Class Rating
IAM	Annual Maintenance Inspection
IMC	Instrument Meteorological Conditions
INMET	National Institute of Meteorology
IS	Supplementary Instruction
ITT	Interstage Turbine Temperature
LABDATA	CENIPA's Flight Recorders Readout and Analysis Laboratory
MAU	Modular Avionics Unit
METAR	Meteorological Aerodrome Report
MLTE	Multi-Engine Land Aircraft Class Rating
MNTE	Single-Engine Land Aircraft Class Rating
MSL	Mean Sea Level
Ng	Gas Generator Rotation Speed Indication
NP	Indication of Propeller Rotation Speed
NRST	Nearest
NTSB	National Transportation Safety Board
OM	Maintenance Organization
PCL	Power Control Lever

PCM	Commercial Pilot License (Airplane category)
PIC	Pilot in Command
PN	Part Number
PPR	Private Pilot License (Airplane category)
P&WC	Pratt & Whitney Canada
QRH	Quick Reference Handbook
REA-SP	Aircraft Special Routes - São Paulo
REDEMET	Brazil's Command of Aeronautics Meteorology Network
ROTAER	Air Routes Auxiliary Manual
SACI	Civil Aviation Information Integrated System
SBMT	ICAO A/D Designator - *Campo de Marte* Aerodrome, *São Paulo*, SP
SBSJ	ICAO A/D Designator - *Professor Urbano Ernesto Stumpf* Aerodrome, *São José dos Campos*, SP
SBST	ICAO A/D Designator - *Santos* Aerodrome, *Guarujá*, SP
SDAG	ICAO A/D Designator - *Angra dos Reis* Aerodrome, RJ
SDUB	ICAO A/D Designator - *Gastão Madeira* State-A/D, *Ubatuba*, SP
SERIPA IV	4th Regional Service for Accident Investigation and Prevention
SI	Special Instruction
SIC	Second in Command
SN	Serial Number
STC/CST	Supplemental Type Certificate
STSB	Swiss Transportation Safety Investigation Board
TM	Technical Memo
TPP	Private Air Services Registration Category
TSB	Transportation Safety Board
UTC	Universal Time Coordinated
VFR	Visual Flight Rules
Vs	Stall Speed
VTI	Initial Technical Inspection

1. FACTUAL INFORMATION.

Aircraft	**Model:** PC-12 **Registration:** PR-WBV **Manufacturer:** Pilatus Aircraft Ltd.	**Operator:** Private
Occurrence	**Date/time** : 01MAI2018 - 20:43 UTC. **Location:** 500m from SDUB runway. **Lat.** 23°26'45" S **Long.** 045°04'57" W **Municipality – State:** *Ubatuba* - SP	**Type(s):** [SCF-PP] Powerplant failure or malfunction

1.1. History of the flight.

At approximately 20:30 UTC, the aircraft took off from SDAG *(Angra dos Reis* Aerodrome, State of *Rio de Janeiro*) bound for SBMT *(Campo de Marte* Aerodrome, *São Paulo*, SP), on a private flight with two pilots and eight passengers on board.

At the beginning of the descent, a failure occurred in the propeller pitch-control system, and the crew decided to make an emergency landing at SDUB (*Gastão Madeira* State-Aerodrome, *Ubatuba*, SP).

After touching down in SDUB, the aircraft performed a maneuver to avoid colliding with an obstacle in the overshoot area of the runway, coming to a stop in a swampy area close to the runway 09 threshold.

The aircraft sustained substantial damage.

The Pilot in Command (PIC) suffered serious injuries, the pilot Second in Command (SIC) and two passengers were slightly injured, while the other six passengers were not hurt.

Figure 1 – View of the aircraft at the crash site.

1.2. Injuries to persons.

Injuries	Crew	Passengers	Others
Fatal	-	-	-
Serious	1	-	-
Minor	1	2	-
None	-	6	-

1.3. Damage to the aircraft.

The left wing broke up close to its root, and there was damage to the entire landing gear assembly. The empennage ruptured and detached completely from the fuselage. The horizontal and vertical stabilizers were destroyed. The right wing and the nose landing gear sustained severe damage.

1.4. Other damage.

Nil.

1.5. Personnel information.

1.5.1. Crew's flight experience.

Flight Experience		
	PIC	SIC
Total	4.500:00	3.200:00
Total in the last 30 days	17:00	17:00
Total in the last 24 hours	00:55	00:55
In this type of aircraft	126:48	120:00
In this type in the last 30 days	17:00	17:00
In this type in the last 24 hours	00:55	00:55

NOTE: Source of Information on the hours flown by the crew: pilots' reports and records of their digital Individual Flight Logbooks (CIV – ANAC's SACI System).

1.5.2. Personnel training.

The PIC did his PPR course (Private Pilot - Airplane category) at the *Aeroclube de Biritiba Mirim*, State of São Paulo in 1995. He was the Pilot Flying at the time of the accident. The PIC had taken training in a manufacturer-certified Class D simulator of the aircraft at Dallas Flight School, Dallas, Texas, USA. He completed such training on 23Sept2017.

In the aforementioned simulator, he practiced emergencies of the aircraft, including abnormality of the Propeller Rotation-Speed Indication (NP), emergency descent with a maximum rate of descent, and landing in a powerless emergency-traffic profile.

The SIC did the PPR (Private Pilot – Airplane category) course at the *Aeroclube de Jundiaí*, State of *São Paulo* in 2010. He had not taken any specific instruction or training in the simulator of the aircraft.

1.5.3. Category of licenses and validity of certificates.

The PIC held a PCM license (Commercial Pilot - Airplane category), and had valid ratings of MNTE (Single-Engine Land Aircraft), HMNT (Multi-Engine Helicopter category), and IFRA (IFR Flight - Airplane category).

The SIC held a PCM license, and had valid MNTE and MLTE (Multi-Engine Land Airplane category) ratings.

On 31Oct2014, the ANAC published the Supplementary Instruction (IS) 61-004, Revision "C", which excluded the TYPE rating for Pilatus PC-12 aircraft, changing it to the MNTE Class (Figure 2).

5.4 <u>Registro de revisões das tabelas de habilitações</u>

5.4.1 **31/10/2014** – Revisão C

ALTERAÇÕES REALIZADAS NA REVISÃO C		
TABELA ALTERADA	INCLUSÕES	EXCLUSÕES
VI		TBM7, PC12 (passam a pertencer à classe MNTE)

Figure 2 – Extract from the IS 61-004, Revision C, published on 31Oct2014.

1.5.4. Qualification and flight experience.

The pilots were qualified and had experience in the type of flight.

The PIC was familiar with the route, and made frequent landings in SDUB.

The SIC stated having 120 total hours on that model of the aircraft, not having taken any training in the simulator. He reported having experience on the route, and having landed in SDUB before.

1.5.5. Validity of medical certificate.

The pilots had valid Aeronautical Medical Certificates (CMA).

1.6. Aircraft information.

The serial number 1129 aircraft was manufactured by *Pilatus Aircraft Ltd.* in 2009, and was registered in the Private Air Services Registration Category (TPP).

The aircraft had a valid Airworthiness Certificate (CA).

The airframe, propeller and engine logbooks were out of date, in disagreement with the ANAC IS No. 43.9-003B.

The last inspection of the aircraft ("Preliminary Inspection" type), with a view to nationalization, was performed by the Synerjet Maintenance Organization (OM) in *Sorocaba*, SP on 23Oct 2017. The aircraft had a total 1,235 hours and 25 minutes at the time of the inspection.

When the accident happened, the aircraft had approximately 1,361 hours of flight.

Before being purchased by the operator, the aircraft had been subject to registration in the United States of America, where it was identified as N129NX.

Still under the American registration, the aircraft was equipped with a four-blade aluminium propeller (model HC-E4A-3D), in accordance with the approved type certificate.

On 04Oct2017, according to the original airframe logbook of the American registration, the four-blade propeller (Part Number HC-E4A-3D, Serial Number KX741) was replaced by the five-blade propeller (PN HC-E5A- 3D STC, SN SA167), as per the Supplemental Type Certificate (STC) No. SA03466CH. The mentioned airframe logbook was closed in Brazil on 21Oct2017.

The ANAC had issued the Supplementary Type Certificate (CST) number 20016S02-03, dated 15Feb2016, which approved the installation of the 5-blade propeller assembly, validating the STC nº SA03466CH in aircraft registered in the Brazilian territory.

On 25Oct2017, the aircraft passed the Initial Technical Inspection (VTI) for purposes of nationalization, with 1,235 hours and 25 minutes of flying time, corresponding to 656 cycles. The propeller assembly had 26 hours of flight, with 9 cycles.

According to maintenance records, the engine was replaced on 06Mar2018 due to Foreign Object Damage (FOD). At the time, a rental engine was installed (model PT6A-67P, serial number PCE-RY0319).

The maintenance tasks included in the service above were the following:

> Task 12-B-71-00-00-00A-920A-A: Engine removal and installation.
>
> Task 12-B-71-00-00-00A-920A-B: Removal and installation of engine components.
>
> Task 12-B-61-10-01-00A-920B-A: removal and installation of the five-blade propeller.

Such tasks were listed in the Maintenance Organization Service Order No. 018/2018, part I and part II, dated 15Feb2018. Only the title page of the document had the signatures of the mechanic who performed the task and of the maintenance inspector.

There were pen marks beside each step of the above tasks. In the task 12-B-61-10-01-00A-920B-A (installation of the propeller assembly), a page of the manual was missing, and there was a page referring to the installation of the four-blade propeller assembly.

As shown in Figure 3, in addition to provision of propeller balancing service, the maintenance installed and adjusted the following components:

- Installed Engine (rental) model PT6A-67P S/N. PCE-RY0319 TSN: 173,3 e CSN: 141 and acessories, see FORM ONE by Pratt & Whitney Canada see block 5 PO #4000745971 dated 04/29/2011
  - ✓ Propeller Governor P/N. 3049558-01 S/N. 17331697
  - ✓ Fuel Control Unit P/N. 3119892-07 S/N. 16877049
  - ✓ Fuel Pump P/N. 3040760 S/N. 010902
  - ✓ Fuel Heater P/N. 3057249-01 S/N. WA41589
  - ✓ Ignition Exciter P/N. 3035889 S/N. NNA11090371
  - ✓ Bleed Valve P/N. 3059835-01 S/N. AHX018164
  - ✓ Torque Limiter P/N. 3055748-01 S/N. C51201
  - ✓ Flow Divider P/N. 3038472 S/N. 9959525383
  - ✓ Overspeed Governor P/N. 3037313 S/N. 17329161
- Propeller Assembly Balancing

Figure 3 – List of components replaced on the occasion of installation of the rental engine.

In addition to the set of tasks described above, the operator also sent the Task 12-B-71-00-00-00A-903A-A (engine adjustments and tests) to the Investigation Committee, as well as a number of various documents containing traceability certificates, boroscopic inspection reports, and propeller dynamic balancing charts, among other topics.

The replacement engine (SN PCE-RY0319) had 173 flight hours (141 cycles) at the time of installation. The aircraft flew 45 hours (50 cycles) with the replacement engine.

On the date of the accident, the aircraft had 1,361 hours and 10 minutes of flight, corresponding to 775 cycles. The engine had 218 hours of flight (191 cycles), and the propeller had 151 hours and 50 minutes of flight (128 cycles).

Propeller Pitch-Change System.

The propeller governor controlled the pitch-change mechanism and the propeller rotational speed by means of the amount of oil directed to the propeller hub. To control the proper pressures of the oil system, there was a pump and a pressure relief valve inside the governor.

Control of the pitch-change mechanism and of the propeller RPM speed was performed by means of two distinct modes of operation: the propeller-governor mode and the beta mode.

From values of 1,700 RPM and above, the propeller-governor mode controlled the flight condition, the pitch angle and the propeller rotation.

In such mode of operation, the beta valve remained open, allowing oil to pass through the Pilot Valve to the propeller piston. The centrifugal force of the propeller rotation was transmitted to the Rotating Flyweights and, as the rotation increased, the centrifugal force also increased, causing the Rotating Flyweights to compress the Speeder Control Spring, which made the Pilot Valve piston move upwards, restricting the supply of oil.

The restriction of oil supply increased the propeller pitch-angle, causing the RPM to decrease.

Conversely, if the rotation was below 1,700 RPM, the centrifugal force would decrease, the Speeder Control Spring would expand, and the Pilot Valve plunger would lower, allowing the passage of oil, causing the pitch angle to decrease and the propeller RPM to increase.

Thus, the rotation was maintained at values close to 1,700 RPM during the flight. Figure 4, adapted from the Aircraft Maintenance Manual (AMM), shows the operation of the propeller governor. The red line represents oil under pressure and the orange line represents oil regulated to the propeller hub.

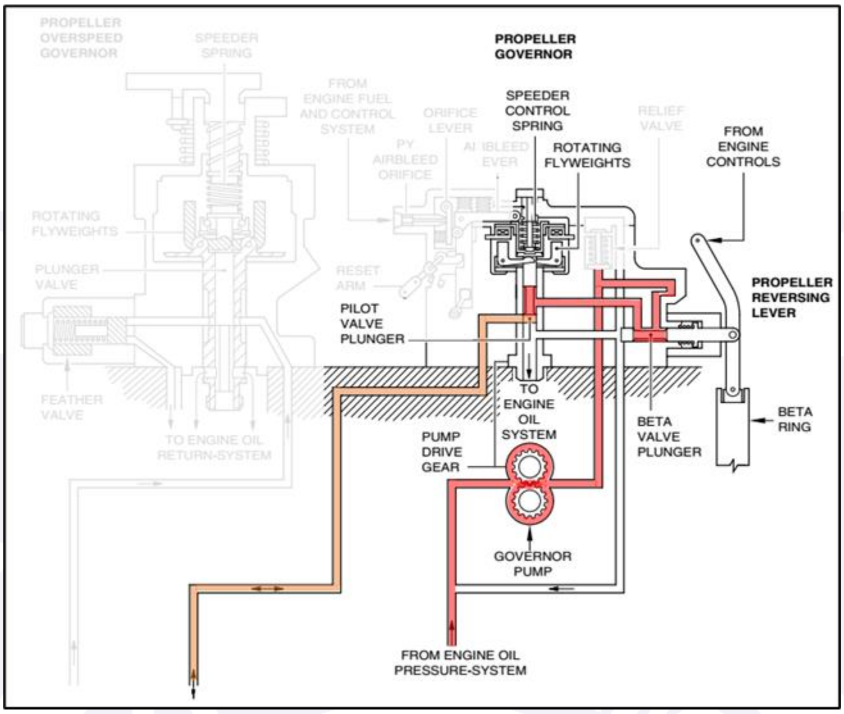


Figure 4 - Propeller governor operating mode.
Source: Adapted from the aircraft's AMM.

With the engine operating in the lower power ranges (ground idle and reverse), the centrifugal force from the counterweights would no longer oppose the force of the Speeder Control Spring. Therefore, the Pilot Valve piston would remain in the distended position, allowing the passage of oil, and no longer controlling the pitch angle of the propeller.

In that condition, the beta valve would control the amount of oil to the propeller hub, its position being determined by the reverse rod connected to the power levers. Such condition received the name of *beta mode of operation*.

With the thrust lever in the reverse position, the beta valve plunger would allow the passage of oil to the propeller hub, and the pitch of the blades decreased until the reverse angle. As the throttle was advanced towards ground idle, the oil flow would become restricted, and the pitch angle would increase (Figure 5).

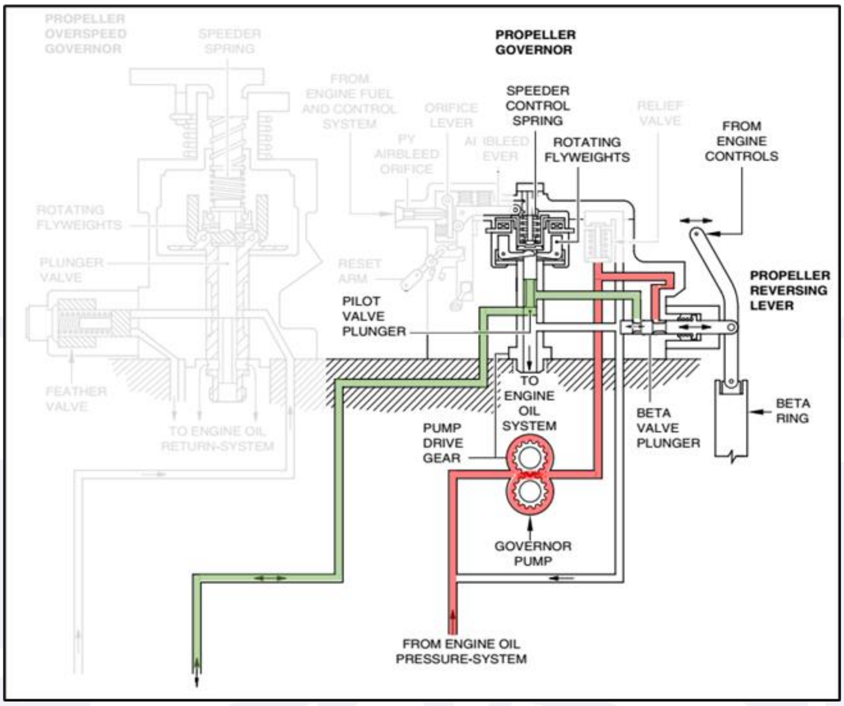


Figure 5 - Beta mode of operation.
Source: Adapted from the aircraft's AMM.

In this mode of operation, the beta rod, located in the propeller hub, started to move together with the sliding piston. The beta rod, in turn, was connected to the beta ring, which connected to the reverse rod and to the beta valve through the carbon block.

As the beta ring was brought forward, the beta rod spring compressed, forcing the ring back to a balanced position. Thus, the pitch angle was controlled by the beta valve.

Figure 6 shows the main components of the propeller pitch-change mechanism.

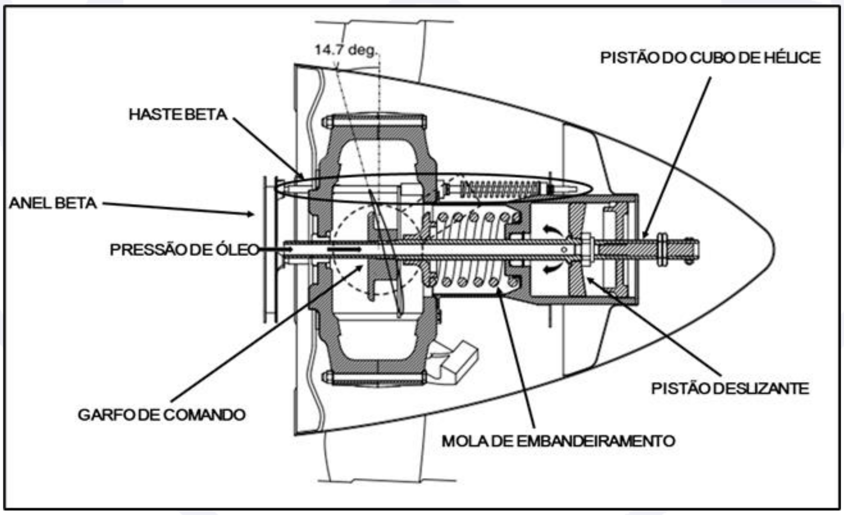


Figure 6 - Components of the pitch-change mechanism in the propeller hub.
Source: Adapted from the aircraft's AMM.

The pitch-change system was also protected against high RPM by means of the overspeed-governor. Inside this component was the feathering solenoid valve, which received an electrical signal when the condition levers were placed in the cut-off position.

<u>Engine Control Levers</u>.

The engine was controlled by the Condition Lever (CL) and by the Power Control Lever (PCL).

The CL controlled the engine operating-regime, and had three positions: Cut-Off/Feather, Ground Idle, and Flight Idle.

The Cut-Off/Feather position was responsible for interrupting the fuel flow.

The CL was held in the position selected by means of teeth, and could be moved forward freely, but to move it backwards it had to be lifted. Additionally, a stop would hinder its inadvertent placement in the Cut-Off/Feather position.

The PCL controlled the engine power, which had both ground and flight operating ranges.

The ground operating range was utilized for the landing procedure with application of reverse power to the engine, and during taxi. With the aircraft in flight, a lock known as Idle Detent Lock prevented the PCL from shifting to the ground operating range. In such range, the propeller-governor operated in beta mode.

The purpose of the flight operating range was to control the engine power during the various phases of the flight, such as climb, cruise, and descent.

1.7. Meteorological information.

At the time the aircraft took off from SBMT, the weather in SDAG was consistent with VFR. The automatic meteorological station of the National Institute of Meteorology (INMET) registered a temperature of 26º C, while the wind was 169º at 6 kt. There was no record of precipitation at any time of the day.

Meteorological conditions between the initial phase of the descent and the moment of perception of the emergency by the crew varied between VMC and IMC.

The Meteorological Aerodrome Reports (METAR) from SBSJ (*São José dos Campos* Aerodrome, 46 NM away from the accident site) had the following information:

METAR SBSJ 012000Z 16005KT 9999 SCT040 20/24 Q1019=

METAR SBSJ 012100Z 20004KT 9999 SCT040 18/23 Q1020=

With the purpose of evaluating the prevailing conditions in the coastal region, the investigators checked the METAR of SBST (*Santos* Aerodrome, *Guarujá*, SP, at a distance of 73 NM from the place of the occurrence):

METAR SBST 012000Z 20004KT 9999 BKN032 26/22 Q1017=

METAR SBST 012100Z 13004KT 9999 BKN032 25/22 Q1018=

Satellite images obtained close to the take-off time and at the time of the occurrence showed the presence of cloud formations on the route flown by the aircraft, with greater density near the coast, as can be seen in Figures 7 and 8.

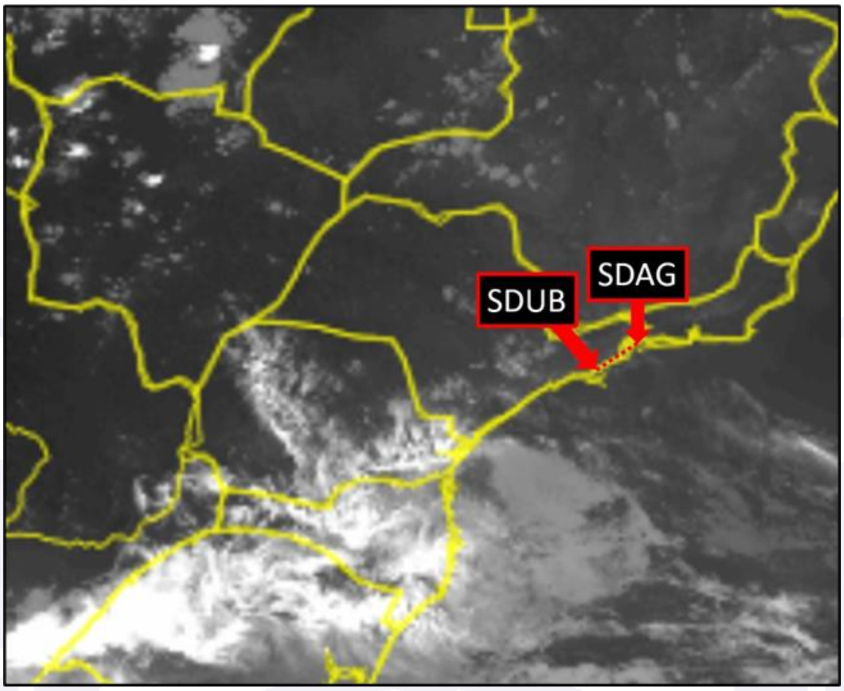


Figure 7 - Infrared satellite image at 20:15 UTC.
Source: *Comando da Aeronáutica* Meteorology Network (REDEMET).

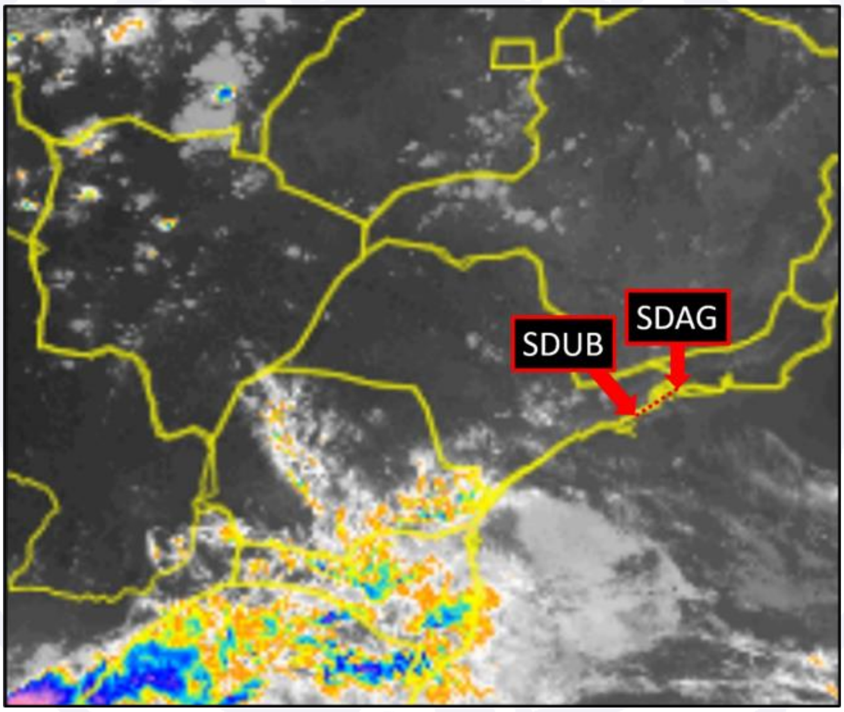


Figure 8 - Enhanced satellite image at 20:15 UTC. Source: REDEMET.

The crew selected to proceed to SDUB for an emergency landing. Meteorological conditions were not favorable for VFR from the returning point on the route until close to the runway.

It is noteworthy that this part of the flight was flown over *Serra do Mar (*mountain range by the sea*)*. There was a cloud layer between FL030 and FL040, which the aircraft needed to pass on its descent to land in SDUB, as reported by the PIC and confirmed by the meteorological data obtained.

With regards to the attempt to land in SDUB, after the aircraft passed the cloud layer (base of clouds at approximately 3,000 ft.) the weather was VMC.

1.8. Aids to navigation.

NIL.

1.9. Communications.

The crew did not contact the Air Traffic Control (ATC) agencies from the moment of perception of the emergency until completion of the forced landing. The pilots reported having communicated via the Aircraft Coordination Frequency (FCA) of the area over which they were flying. For this reason, it was not possible to obtain a recording of their communication from the ATC services.

1.10. Aerodrome information.

The aircraft made a forced landing at a distance of approximately 500 meters beyond the approach end of SDUB runway 27.

SDUB is a public aerodrome under the administration of *Voa São Paulo*, operating VFR during daytime. It does not provide either air traffic control or flight information services. FCA communications are available on 124.525 MHz.

The asphalt runway has the thresholds 09/27, measuring 940m x 30 m, at an elevation of 10 ft. On the day of the accident, the sunset was at 20:33 UTC.

According to information contained in the Air Routes Auxiliary Manual (ROTAER), the first 380 meters of runway 09 were unavailable for landing (corresponding to the last 380 m of runway 27, not available for takeoff.

1.11. Flight recorders.

In addition to having a Cockpit Voice Recorder (CVR), the aircraft was equipped with an Aircraft Condition and Monitoring System (ACMS) and a Fault History Data Base (FHDB), both of them part of the avionics suite, which recorded data both from the flight and from the aircraft systems.

Data download could be performed to aid in troubleshooting or for operational evaluations. As per the Technical Memo (TM) TM-12-006531 produced by the aircraft manufacturer, such data was not impact-resistant like a Flight Data Recorder (FDR) or CVR, but could be useful in investigations when available, which was the case in this investigation.

It was possible to extract and retrieve additional information from the ACMS by means of the Modular Avionics Unit (MAU), which recorded data at a frequency of 1 Hz. All 30 minutes prior to impact were recovered and tested for reliability.

The pictographic representation of the route flown by the aircraft was based on ACMS data, which also allowed the re-creation of the flight in a simulator of the CENIPA's LABDATA.

The investigation committee sent the cockpit voice recorder to the NTSB in the United States for readout of the communications exchanged by the crewmembers in the cockpit. However, it was not possible to extract any recordings related to the accident, nor was it possible to determine why the CVR had not recorded such communications.

1.12. Wreckage and impact information.

The aircraft collided with the ground about 500 m beyond the runway of SDUB. The distribution of the wreckage was of the concentrated type.

The area near the runway is swampy, featuring small trees and undergrowth. The evidence indicated a collision of the aircraft left wing against one of the trees on the ground, making it separate from the fuselage. The event also reduced the distance necessary for the aircraft to stop.

The right wing collided with the vegetation as well, but remained attached to the structure. Except for the aircraft occupants, there were no other observers of the crash.

. Figure 9 - Position of the wreckage at the removal.

1.13. Medical and pathological information.

1.13.1. Medical aspects.

There was no evidence that issues of physiological nature or disability affected the crew performance.

1.13.2. Ergonomic information.

NIL.

1.13.3. Psychological aspects.

The PIC had been working in aviation for 24 years. In September 2017, after a period of 2 years out of work, he was hired as a pilot by the company to which the occurrence aircraft belonged.

Most of his professional experience was in the executive aviation, with a total 4,500 flight hours, 126 hours of which in the Pilatus PC-12 aircraft (NG model), with several flights performed in the region where the accident happened.

According to the PIC, his work in aviation was always safety centered. He made a point of keeping his CRM up to date, besides attending flight-safety lectures, taking up courses, and planning all the phases of flight.

The PIC considered having performed good CRM, with assertive communication and division of tasks. He reported having remained calm until the end of the occurrence.

He declared that he had not been experiencing any personal, family and/or social problems, and had not been facing any problems related to his physical and mental health in the past months. He was happy with his working conditions, remuneration, work environment, and interpersonal relationships. According to him, the flights were always scheduled in advance so that they could do the planning with peace of mind, and there was never any pressure from the company for a flight to take place.

Regarding his working hours, the PIC said that he did not have any other remunerated activity besides his work as a pilot for the company.

The PIC reported that the night before the occurrence he had enjoyed a peaceful and restful sleep. He was a fan of physical activities, and had no relevant facts or concerns capable of interfering with his professional performance at the time of the accident.

On the day of the flight, the pilots traveled from *Jundiaí* to SBMT well in advance to prepare the aircraft and flight details with ease.

The PIC reported having an excellent personal and professional relationship with the SIC composing the flight crew, with his other work colleagues, with his fellow pilots, with the administrative staff of the hangars and workshops, with the runway staff, and others.

Still according to the interviews, they were flying VMC, but the meteorological conditions over the mountains were bad, and they believed that the weather in SDUB (elected and defined by them as a better landing option) was not good either. However, according to the calculations made by the crew after the in-flight propeller-feathering event, SDUB would be their only chance.

The pilots informed having stayed calm and serene inside the cockpit. Furthermore, they mentioned that, despite having noticed the abnormal condition, they remained with the expectation that the failure could be sorted out spontaneously by the equipment itself.

The SIC did his pilot training at the *Aeroclube de Jundiaí* between 2008 and 2012. According to information gathered, courses on Jet Training, Performance-Based Navigation, and CRM were also attended by him.

He had worked as a flight instructor at *Aeroclube de Jundiaí* from 2012 to December 2017, having flown approximately 3,000 hours on aircraft such as the C152, C172, and PA34. On the occurrence aircraft, he had logged approximately 120 hours of flight time.

He reported that, during his flights, he always sought to maintain a standardized operation, focused on safety, a culture that he had previously acquired while working as a flight instructor, at a time when he regularly participated in lectures promoted by the Operational Safety Manager of the *Aeroclube*, with the purpose of instruction standardization.

The SIC informed that, at the time of the accident, he was very satisfied with his new job, flying a more advanced aircraft, and without any health or personal problems that could have affected his performance on the occurrence flight.

The day before the accident, he had a good uninterrupted night's sleep of about 8 hours. His routine working day was limited to scheduled flights, with regular breaks. He was happy with his working conditions, and had no complaints related to excessive workload or fatigue.

According to the SIC, his relationship with the PIC was very good all the time, and they always managed to have good CRM during flights. The company provided for good working conditions, without ever pushing on or questioning their decisions regarding the operation.

1.14. Fire.

There was no fire.

1.15. Survival aspects.

At the impact, all the aircraft occupants were wearing their seat belts. The PIC (sitting in the left seat) suffered injuries in the clavicle region, due to action of the harness against his torso resulting from aircraft deceleration at the impact. None of the injuries resulted from deficiency or misuse of the belts and harness.

The evacuation of the aircraft occupants had the assistance of two military-police officers who stayed in the area until the fire-and-rescue team arrived. All occupants disembarked through the main door of the aircraft.

1.16. Tests and research.

With the purpose of understanding the events that triggered the accident, the stakeholders carried out several analyses of the aircraft powerplant and its components. All of such analyses had participation of representatives of the investigation committee.

The PT6A-67P engine (SN PCE-RY0319) equipping the aircraft at the time of the accident was examined on the premises of Pratt *& Whitney Canada (P&WC) do Brasil* facilities, and was later sent to Canada for more detailed investigation at the P&WC facilities of Saint-Hubert, where functional tests were performed on a dynamometer. The manufacturer representative in Brazil (Diamond Company, in *Goiânia*, State of *Goiás*) analyzed the propeller. The component manufacturer (Woodward Company, Colorado, USA) analyzed the propeller-governor and overspeed-governor on their premises.

The engine had no evidence of pre-impact damage that could have affected its ability to generate power.

The components of the propeller pitch-change mechanism had their original positions altered, possibly due to the process of transporting the crashed aircraft from the accident site to the location where it was stored for subsequent examinations. For this reason, and because of any alterations resulting from the removal of the accessories and propeller, it was not possible to verify aspects related to the installation of such components on the aircraft.

The analyses initiated with a visual inspection of the engine, in which there was neither damage to the structure nor leakage of lubricating oil. There were not any abnormalities in the connections and tubes of the pneumatic line.

There was inspection of the main oil filter, reduction box and gearbox filters, as well as of the fuel pump and pneumatic line filters. In none of them were there any filings or any other contaminant capable of compromising the functioning of the engine.

Relatively to the bench tests, all inspection procedures were repeated, and an internal check of the engine was performed by means of a borescope. After verification that there was no evidence of rubbing, the engine was installed on the test bench for functional testing.

After installation and start-up of the engine, the technicians found an oil leak in the oil-return pump pipes. This leak was due to a small displacement of the oil-return pipe resulting from the forced landing. The pipe was disassembled, cleaned, and reinstalled. The engine was restarted, and no leaks appeared afterwards.

During the test, the engine operated normally, providing full response to all the test demands, without any noticeable discrepancies or abnormalities.

<u>Analysis and disassembly of the propeller.</u>

The propeller was subject to analysis by a certified maintenance organization, which also performed bench tests for pitch-angle change, measurement of beta ring distances, opening of the propeller assembly, and inspection of the feathering spring.

Prior to removing the propeller from the engine, one measured the carbon block clearance, which was within the limits provided by the manufacturer.

The pitch-angle change test, the opening of the propeller assembly, and the inspection of the feathering spring showed no discrepancies.

However, the measurement of the beta-ring distance indicated that the ring displacement was not within the manufacturer's prescribed limits (Figure 10). It was not possible to identify whether such displacement resulted from a maintenance action or from some event during the assembly of the ring upon replacement of the propeller. Nevertheless, one considered that such discrepancy might have occurred due to the impact sustained by the propeller blades in the emergency landing.

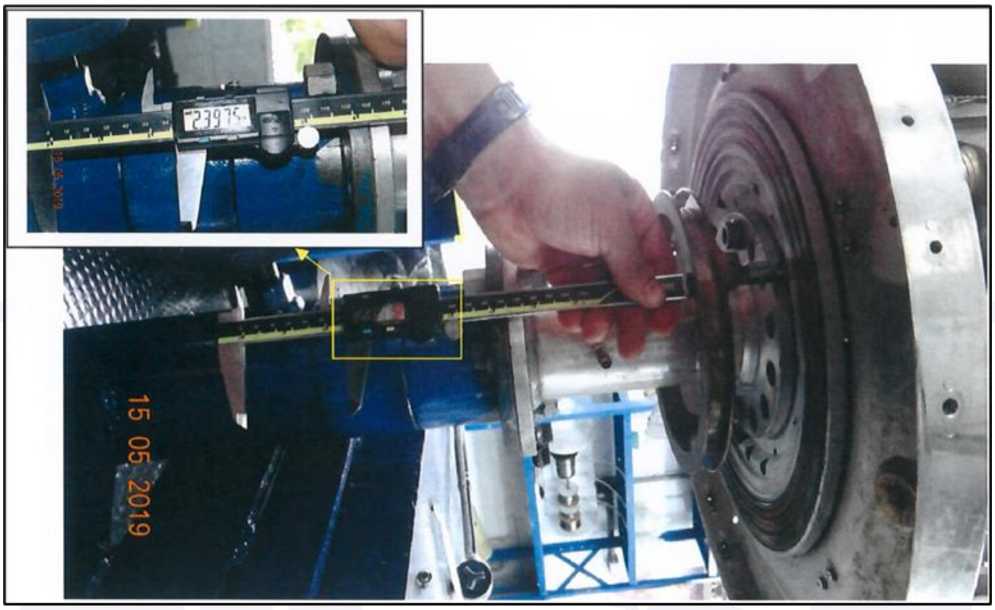


Figure 10 - Verification of the distance between the sliding ring and the propeller plate during the assembly process.

The other individual tests of the components of the propeller pitch-change mechanism revealed no abnormalities.

Propeller-governor tests and analysis.

The propeller-governor had small marks and scratches consistent with the impact. In the preliminary inspection, one verified that there were brake wires different from the standard ones utilized by the manufacturer.

All of its internal components were in good operating order. However, one found out that the in-field adjustments were outside the limits prescribed by the manufacturer of the component.

With the purpose of verifying the sensitivity of the beta valve adjustment, the investigation committee conducted a test-bench simulation with a propeller-governor similar to the one of the occurrence aircraft.

The test allowed verifying that, once the drop in oil pressure in the propeller hub started, it no longer recovered, until reaching values close to zero. The sequence of images depicted in Figure 11 shows the normal working pressure of the governor, followed by the drop in oil pressure until it reaches a zero value. There was no intervention by the bench operator after the start of the pressure drop. The instant the pressure reached zero, the beta valve locked.

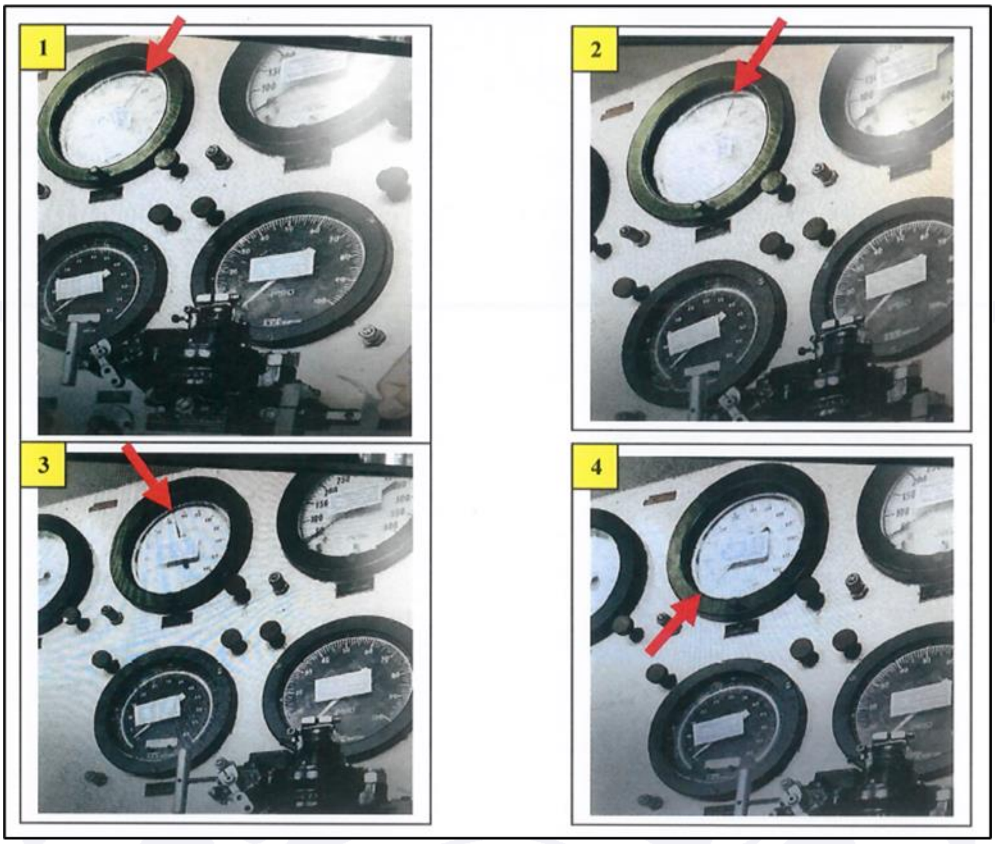


Figure 11 - Test bench operation of the beta valve of the propeller-governor similar to the one of the occurrence aircraft, showing the drop in hydraulic pressure.

Aircraft electricity tests.

After the series of tests of the components mentioned above, one made the decision to perform electricity tests on the aircraft (Figure 12) in order to verify the functionality of the circuit of actuation of the propeller feathering solenoid valve. The procedure selected was the "PC-12/47E MSN1129 - Propeller Feather System Test" developed by the manufacturer.

. Figure 12 - Conducting electricity tests on the aircraft.

The condition of continuity and isolation of the solenoid valve circuit did not present failures, except when one placed the CL in the Cut-Off/Feather position, and measured the isolation with other buses that did not feed the feathering solenoid valve.

In other words, the sub-item 4 of the procedure (*Verification of the propeller feather power supply*) required the CL to be in the CUT-OFF/FEATHER position in order to verify whether the propeller feathering valve could be inadvertently activated with energy from another bus (as in the case of a short circuit due to a loose wire). One verified the existence of continuities in the measurements of all buses. The “EPS BUS LH REAR” was in short circuit (0 ohm), and changed to 328 ohms only when one placed the “EPS IN” circuit breaker in the “open” position.

Physicochemical testing of the lubricating oil.

A sample of lubricating oil extracted from the engine's accessory box was subject to physicochemical testing. The result obtained in the kinematics viscosity test at 100ºC was stable, above the value specified by the Norm MIL-PRF-23699G, as shown in Figure 13.

CARACTERÍSTICA	Especificado pela MIL-PRF-23699G	AMOSTRA ÓLEO LUBRIFICANTE ANV PR-WBV
1.1. Viscosidade Cinemática a 100 °C (mm^2/s)	4,9 a 5,4	5,7 ± 0,2
1.2. Viscosidade Cinemática a 40 °C (mm^2/s)	23 (mín.)	28,4 ± 0,2
2. Ponto de Fulgor Cleveland (°C)	246 (mín.)	261 ± 1

Figure 13 - Values specified and results obtained from the sample of lubricating oil.

1.17. Organizational and management information.

The operator of the PR-WBV aircraft was private, and had an employee responsible for the management of the equipment and its documentation.

According to interviews, the management prepared the schedule of the aircraft flights in advance, which made it possible to do adequate flight planning. The company had decided to hire a second pilot to compose the crew, even though the aircraft could operate with just a single pilot.

As for the maintenance of the aircraft, the PIC reported having full autonomy with regard to the management of the aircraft maintenance, and informed that he did not have any financial obstacles on the part of the company in this regard. He informed that it was customary for him to accompany the aircraft whenever it was subject to periodic inspections or repairs in maintenance workshops.

1.18. Operational information.

The first leg of the occurrence flight originated in SBMT, bound for SDAG. The pilots did the flight planning, and reported having performed both the briefing and pre-flight inspections. According to statements made by them, they did not observe anything unusual during that stage of the flight. According to data extracted from the ACMS and FHDB, the first signs of abnormality started in SDAG, after their arrival and boarding of the passengers.

However, the pilots reported that, after installing the rental engine, the ENGINE NP warning light began to illuminate with some frequency after engine start-up and while taxiing.

The recurrent illumination of the NP warning light led the pilots to take the aircraft for verification at the maintenance organization responsible for the engine replacement. The OM performed ground tests monitored by a company inspector, but nothing out of the routine appeared. They gave the compressor and its turbine a desalinization wash, and released the aircraft for return to operation. The mentioned services took place on 10Apr2018, i.e., twenty-one days before the accident.

The crew reported that the ENGINE NP warning light continued to illuminate after takeoff and during taxi on the flights conducted before the day of the accident.

On the date of the occurrence, after landing in SDAG, the aircraft remained on the ground for about two hours before the passengers boarded.

According to the TM-12-006531, in the period between engine start-up and aircraft take-off, there were two drops (20 seconds each one) in propeller rotation (NP) with values below 950 RPM. The ENGINE NP CAUTION CAS MESSAGE light illuminates if:

> The message is posted if a Red Propeller NP Warning is not present and:
>
> NG ≥ 90% and NP ≤ 1640 rpm for more than 5 seconds, or
>
> NP > 1760 and NP ≤ 1870 rpm (1870 rpm and up gives a Red Propeller NP Warning), or
>
> With aircraft on ground and propeller not feathered, NP is between 350 and 950 rpm for more than 15 seconds.

The Aircraft Flight Manual (AFM) had the following note in the engine start-up section:

NOTE

If the propeller rpm after engine start-up is below 950 rpm, refer to Para. 3.6.2 in the Emergency Procedures section. If NG is below 60% after start-up, refer to Para. 3.6.3 in the Emergency Procedures section.

Figure 14 - Extract from section 4.5.1, “Engine Start” of the AFM.

. The emergency procedure of the item 3.6.2, shown in the NOTE above, was the ENGINE NP procedure, fully expressed in the Figure 15 below.

3.6.2 ENGINE NP

Indication: CAS warning or caution - Engine NP

A. ON GROUND IMMEDIATELY AFTER ENGINE START

1.	**NP**	**Check NP RPM indication**
	If propeller RPM is below 950:	
2.	**Select as convenient either:**	
	CONDITION LEVER	**FLIGHT IDLE**
	or	
	ELECTRICAL HEAT/COOL	**INHIBIT**
	or	
	ACS BLEED AIR	**INHIBIT**
	or	
	PCL	**Retard aft of idle detent until NP is above 950 rpm**

B. ON GROUND

1.	**NP**	**Check NP RPM indication**
	If propeller RPM is below 930:	
2.	**PCL**	**Retard aft of idle detent or increase power until NP is above 950 rpm**
	If propeller RPM is above 1760:	
3.	**PCL**	**Reduce power**

Figure 15 - ENGINE NP emergency procedure, extracted from the aircraft's Quick Reference Handbook (QRH).

In the interview, the crew reported that the warning light did not illuminate during taxi, and that they did not perform the procedures described above. Based on information from the TM-12-006531, it was not possible to determine whether the speed recovered to values above 950 RPM after pilot intervention, or due to stabilization of the system itself.

The occurrence aircraft took off from SDAG at 20:14 UTC. The aircraft climbed to and maintained FL 145, without any event or abnormal condition appearing in that interval. The

NP remained slightly below 1,700 RPM, with values between 1,685 and 1,695 RPM, a fact considered normal as per the manufacturer's manual.

According to the crew, a few moments after starting descent, with the aircraft heading *REPRESA SUZANO* fix, and maintaining the coordination frequency of the Aircraft Special Routes corridors - *São Paulo* (REA-SP), the PCL was reduced, and the descent-torque selected. At that moment, the crew heard the noise of propeller feathering, and noticed the pitch-change of the blades. Then, the ENGINE NP light illuminated, and the propeller RPM began to drop rapidly and continuously.

The pilots' report became easier to understand after the analysis of the data extracted from the ACMS, in which the investigators verified that at 20:33:50 UTC, 22 seconds after engine reduction, the propeller speed began to fall progressively. At 20:34:15 UTC, the first ENGINE NP warning appeared, followed 20 seconds later by another one, as seen in Figure 16 (extract from the animation based on the flight data).

. Figure 16 – Moment at which the abnormal condition appeared, on a Simulation based on the flight data retrieved. Source: LABDATA, CENIPA.

The first reaction by the crew was to look up the corresponding emergency in the checklist, but they did not find it (*in-flight NP light on*). The SIC reported having sought the emergency corresponding to the condition observed by them (*propeller feathering in flight*). The PIC asked the SIC to take over the aircraft controls so that he (the PIC) could try to find it. There was difficulty in recognizing the emergency in the QRH. The procedure prescribed in the QRH and AFM in case of *ENGINE NP - In flight* warning-light illumination was described according to Figure 17. The pilots reported having applied the corresponding procedures, without success.

C. IN FLIGHT

1.	**NP**	**Check NP RPM indication**
	If propeller RPM is below 1640:	
2.	**PCL**	**Increase power**
3.	**Aircraft speed**	**Increase**
	If propeller RPM is above 1760:	
4.	**PCL**	**Reduce power**
5.	**Aircraft speed**	**Reduce**
	If NP remains between 1760 and 1870 RPM	
6.	**Aircraft**	**Continue flight, at low aircraft speed, using minimum possible power.**
	If NP is above 1870 RPM:	
7.	**PCL**	**Reduce power (to idle if necessary)**
8.	**Aircraft speed**	**Reduce to 120 KIAS or below**
9.	**Aircraft**	**Land as soon as possible, using minimum power. If possible always retain glide capability, to the selected landing airfield, in case of total propeller failure**

Figure 17 - "ENGINE NP - In flight" emergency procedure, extracted from section 3-14 of the AFM, revision 17, of 12Jul2017.

On their own initiative, the crew decided to close the bleed air, and turn off the air conditioning system.

No emergency was declared to the ATC agencies.

The crew, then, tried to apply power by means of the PCL, but there was no "un-feathering" response, just an increase of the Interstage Turbine Temperature (ITT), fuel flow, and torque.

The crew attempted to apply different torque regimes; however, even taking the PCL to full speed, the NP rose at most to values close to 600 RPM. The PIC requested that the SIC try different CL regimes, but again they received no pitch-change response. According to them, the condition resembled "*accelerating a car in neutral gear*".

The aircraft's QRH described the emergency "Engine Failure in Flight - Partial Power Loss" (Figure 18), whose signs would be either the un-commanded reduction of engine power, or lack of response to the movement of the PCL.

ENGINE FAILURE IN FLIGHT - Partial Power Loss

Indications: Un-commanded engine power reduction. No response to PCL movement.

NOTE

Below NG 58% the ACS will go off. At approx NG 35% both generators will go off-line.

1. PCL	**Idle**
2. Manual Override Lever	**Pull upwards and move slowly forward until engine responds, wait and let engine stabilize**

If engine compressor stalls and/or ITT exceeded:

3. Manual Override Lever	**Retard and move very slowly forward**

If NG falls below 50%:

4. Starter	**Push momentarily**

NOTE

When the starter is engaged both generators will go off-line and Main, AV2, Non Ess, Cabin, GEN 1 and GEN 2 busses go off. Upper MFD and copilots PFD will go blank. 7.5 sec after NG is > 50% both generators will automatically come on-line and the ACS will come on at NG > 62%.

5. Manual Override Lever	**Move forward to required power (NG > 80%)**
6. Aircraft	**Land as soon as practical.**

CAUTION

When MOR is in operation, do not permit NG to fall below 75% and observe engine limitations.

In descent and until touch down:

7. Manual Override Lever	**Maintain at least 75% NG.**

WARNING

Depending on airfield conditions and aircraft weight and configuration, the available power might not be sufficient to ensure a go around.

After touch down:

8. Condition lever	**Cut-off/feather**

WARNING

Do not move PCL aft of idle detent.
Total landing distance is increased by a factor of 2.

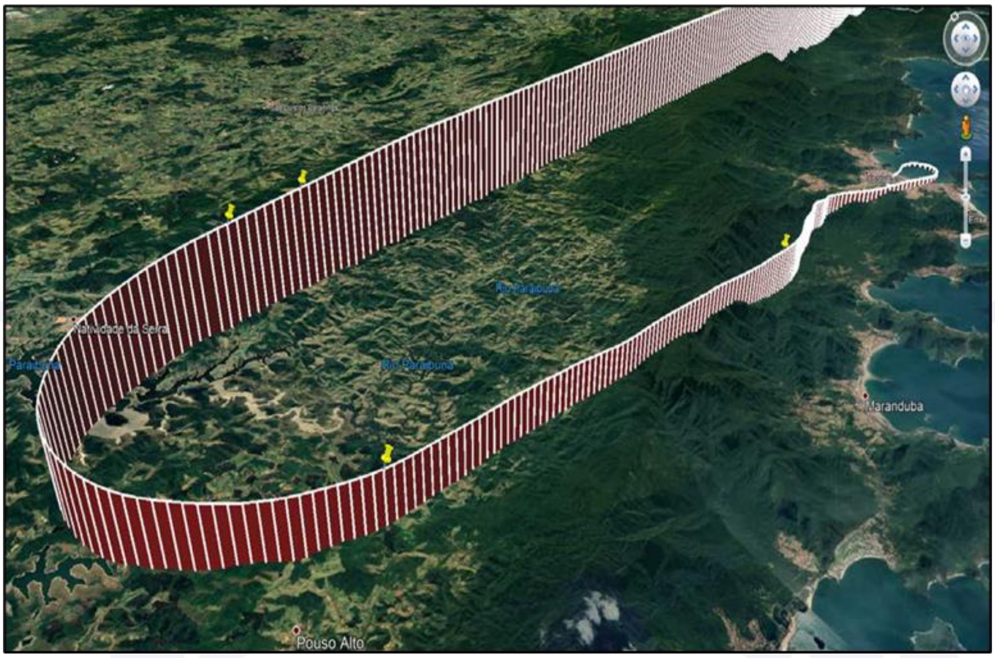
Figure 17 - Procedure prescribed in the QRH for in-flight engine failure - partial loss of power.

The crew reported not having considered taking TOTAL POWER LOSS or PARTIAL POWER LOSS actions, as they did not correlate that situation to an engine failure specifically. In addition, they reported that they did not consider the option of shutting down the engine, due to the consequent loss of equipment connected to the generator, screens, etc.

The autopilot was disengaged at 20:34:49 UTC, with the aircraft still maintaining the heading flown before at cruise altitude. The engine power continued to decrease until the NP reached the lowest registered value, stabilizing at 266 RPM.

At that moment, after calculations made by the SIC that it would be possible to reach SDUB, a result obtained with assistance of the NRST (nearest) function of the GPS, they made a left turn towards the selected location, as shown in Figure 19.

SDUB was approximately 19 NM away from their position. The crew reported having calculated that their altitude AGL was sufficient to fly over the *Serra do Mar* (mountain range), a natural obstacle on the route to SDUB.



. Figure 19 – Route flown by the aircraft, showing the left turn made towards SDUB.
The four points (highlighted in yellow) refer to the registered NP CAUTION CAS warnings.

Considering the point of the left-turn initiation, SBSJ runway was at a distance of 27 NM, at an elevation of 2,123 ft. It is noteworthy that the failure occurred at an altitude slightly over 13,500 ft., and they started the turn at an altitude of approximately 12,800 ft.

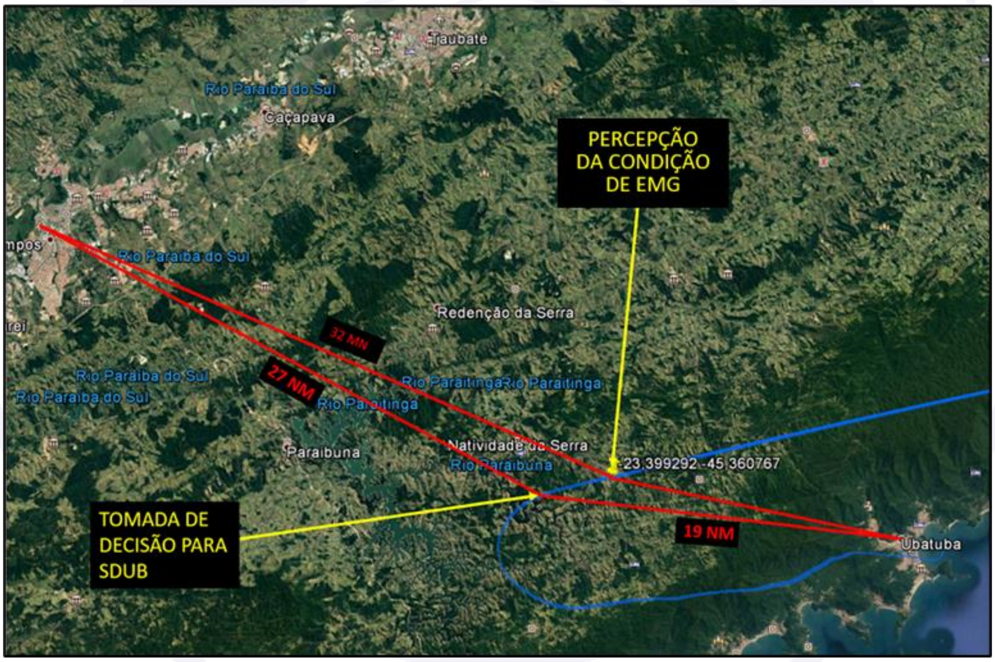


Figure 20 - Distances from the point where the crew decided to proceed to SDUB:
SBSJ (27 NM) and SDUB (19 NM).

According to the emergency descent profile diagram (Figure 21), taking into consideration that the aircraft altitude was 12,800 ft., and that SBSJ was at an elevation of 2,123 ft, the maximum range the aircraft reach would be less than 28 NM, which meant that, probably, the aircraft would not arrive at that location in proper condition for a landing.

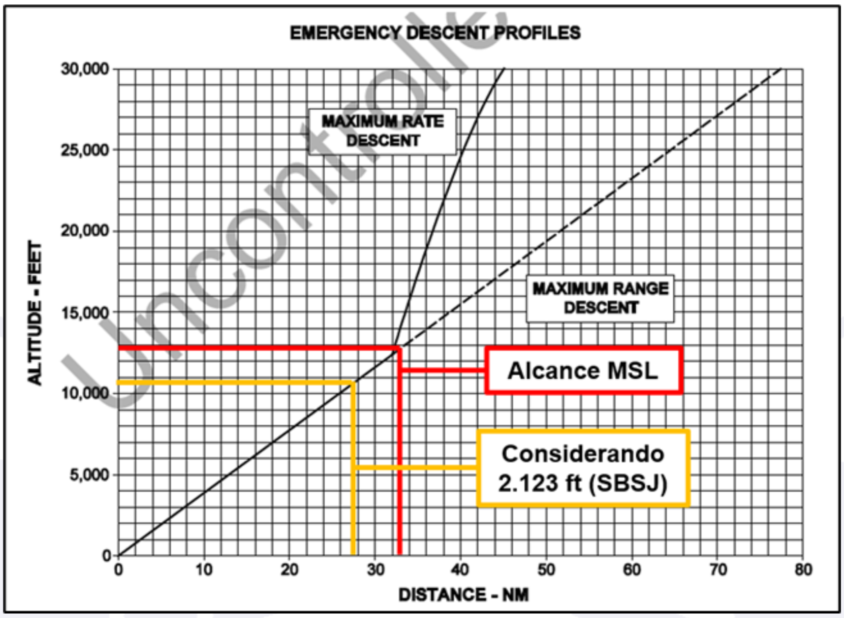


Figure 21 - Maximum range in an emergency descent, considering a shutdown engine and a feathered propeller.

SDUB runway 27 had 940 meters available for landing. According to the performance diagrams available in the AFM (Figure 22), with a speed of 1.3 Vs and flaps at 40º, the total distance required for landing would be less than 700 m, considering average braking and use of IDLE after touchdown. The calculated stall speed for that condition (flaps at 40º), for a maximum bank of 15º on final, would be 63 kt. The ideal speed for such an approach, therefore, would be close to 82 kt.

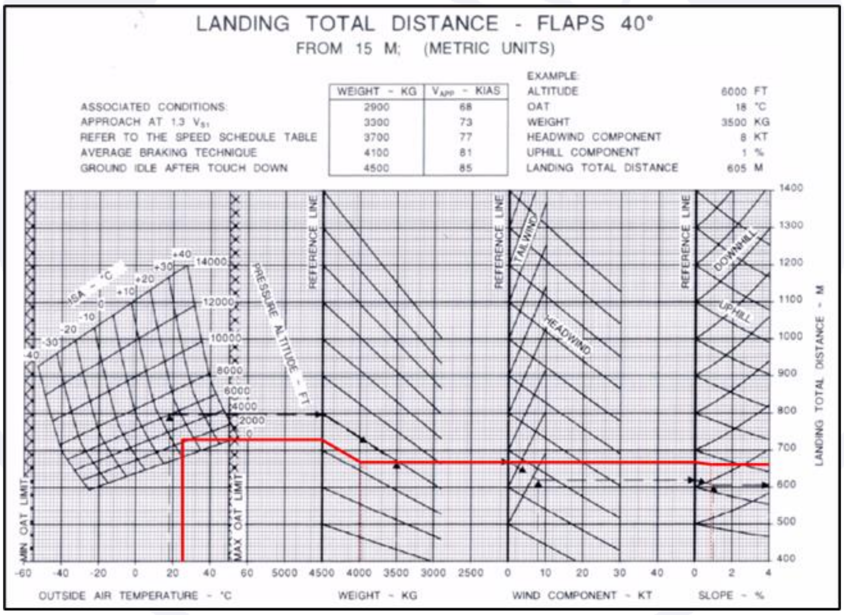


Figure 22 - Total distance required for landing in SDUB with the PR-WBV condition.

According to the data extracted, in the first 3 minutes after the failure, the aircraft maintained an indicated speed above 200 kt, and then gradually slowed down, gliding at a speed between 150 kt. and 160 kt., and reached 140 kt. seven minutes after the onset of the failure. The aircraft reached the speed of 120 kt only once, and maintained it for a period of less than 30 seconds. Then, it accelerated to speeds that reached up to 220 kt.

As reported by the PIC, the purpose of increasing the rate of descent (and consequently the aircraft speed) was to cross the cloud layer, but there were times when the aircraft entered IMC before overcoming the cloud layer between 4,000 ft and 3,000 ft.

It is worth taking into account that the airfield operated only during daytime, and that the occurrence took place close to sunset. According to the pilots, this was one of the reasons for them to maintain an aircraft speed above the one prescribed.

After crossing the layer, the PIC adopted an altitude above the ground consistent with joining the downwind leg of SDUB runway 27. He also reported not having observed the speed at that moment because of the aircraft weight, as the focus was to find a suitable place to land.

Both the AFM and the QRH, when describing the in-flight engine failure procedure - total power loss, recommended the aircraft's best glide speeds as shown in Figure 23.

ENGINE FAILURE IN FLIGHT – Total Power Loss

1. Autopilot	**Use SPD (best glide speed) and HDG/T or NAV mode**
	Best Glide (Propeller feathered):
	10'450 lb (4'740 kg) 119 KIAS
	9'920 lb (4'500 kg) 116 KIAS
	9'040 lb (4'100 kg) 110 KIAS
	8'160 lb (3'700 kg) 105 KIAS
	7'280 lb (3'300 kg) 99 KIAS
	6'400 lb (2'900 kg) 93 KIAS
2. PCL	**Idle**
3. Condition lever	**Cut-off/feather**
4. Aircraft	**Proceed to nearest airfield or landing site avoiding high terrain**
5. Remaining fuel	**Check**

6. Carry out **AIR START** **(next page)**

If cabin altitude is above 10'000 ft:

7. Carry out **EMERGENCY DESCENT**

If engine air start is not successful:

8. Carry out **EMERGENCY LANDING** **for a forced landing**

Figure 23 - Emergency procedure for total loss of power,
with best gliding speeds. Source: AFM, Emergency Procedures.

Considering the approximate aircraft weight at the time of the occurrence to be 4,000 kg, featuring a feathered propeller and a shutdown engine, the recommended speed would be 110 kt.

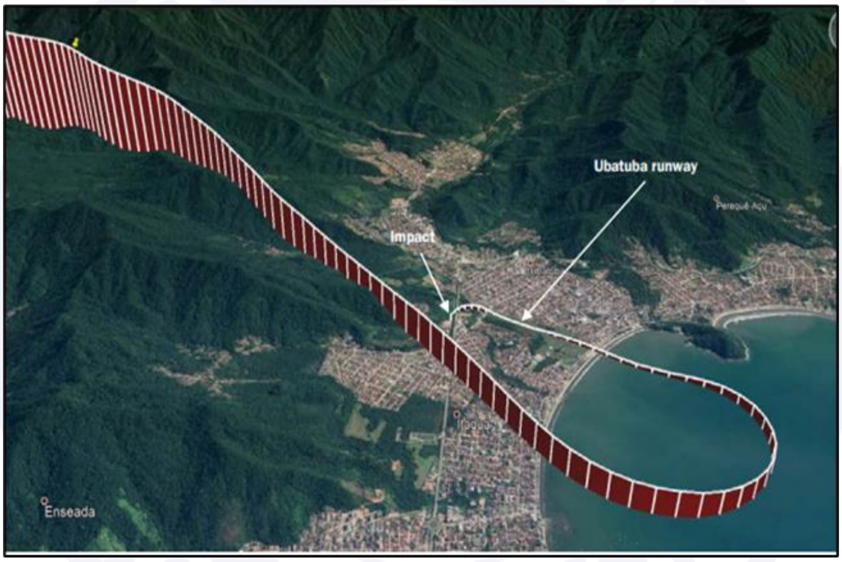
Variations in some of the engine parameters followed, with the NP reaching values close to 600 RPM and, sometimes, even showing signs that it had regained parity with the other engine parameters, a possible indication that there was a certain degree of NP control, since there was variation of the propeller-blade angle.

The crew made a traffic circuit via the south sector, joining in for a landing on the runway 27 of SDUB with a left turn. The aircraft speed on the base leg was 165 kt. The landing gear was lowered at about 150 ft. above the runway at a speed of approximately 150 kt. They started lowering the flaps at approximately 120 ft. AGL.

The aircraft passed over the threshold at a speed of 116 kt, with the landing gear down and with flaps at 16º still in motion. The crew realized that they had a lot of energy, “flying over the runway”. The touchdown occurred at a speed of about 105 kt, between the middle and the last third of the runway, as shown in the static image extracted from the re-creation of the flight in the simulator (Figure 24).

Figure 24 - Touchdown of the aircraft on the SDUB runway.

After the touchdown, according to the crew, upon seeing that there were houses and parked cars in the overshoot area of the runway, the PIC decided to exchange speed for height in order to deviate the aircraft to the left toward an unpopulated swampy area. Figure 25 depicts the final route taken by the aircraft (in highlight).



. Figure 25 - Base turn, landing attempt, and final turn before impact.

The SIC reported that, during the turn before the forced landing, he depressed the right pedal to avoid a left-wing stall. The crew had the perception that most of the impact-energy dissipated when the left wing hit a tree, in addition to having noticed that the landing took place with the aircraft in a pitch-up attitude.

After the aircraft came to a stop, the SIC shut down the engine, the aircraft was de-energized, and passenger evacuation procedures were carried out.

The aircraft was within the weight and balance limits specified by the manufacturer. The approximate weight of the aircraft at the time of the accident was 3,983 kg (8,781 lb.).

The aircraft QRH, at the introduction of the “emergency descent” procedure, listed the following considerations, as shown in Figure 26:

EMERGENCY DESCENT

General

The type of emergency descent will depend on the kind of failure and the aircraft situation.

Two types of descent are considered:
1. Engine failure, aircraft flown for maximum range.
2. Engine running, maximum descent rate.

The factors to be considered are:
- Cabin altitude and oxygen duration.
- Electrical power endurance.
- Distance to suitable landing area.
- Flight conditions IMC, VMC, ICING.
- Minimum safe altitude.
- Fuel reserves.

The pilot must consider the situation and priorities and adjust his actions accordingly.

Figure 26 - Initial description of the emergency descent procedure.

Source: AFM.

Finally, Picture 27 shows the procedure prescribed in the QRH for a landing in emergency condition.

3.9.2 FORCED LANDING (ENGINE CUT-OFF/FEATHER)

1.	**PCL**	**Idle**
2.	**CONDITION LEVER**	**CUT-OFF/FEATHER**
3.	**FUEL EMERG shut off**	**Pull**
4.	**CABIN PRESSURE switch**	**DUMP**
5.	**Best glide speed**	**119 KIAS for 10450 lb (4740 kg)** **116 KIAS for 9920 lb (4500 kg)** **110 KIAS for 9040 lb (4100 kg)** **105 KIAS for 8160 lb (3700 kg)** **99 KIAS for 7280 lb (3300 kg)** **93 KIAS for 6400 lb (2900 kg)**
6.	**Seat backs**	**Upright**
7.	**Seat belts**	**Fastened. Tighten lap straps**
8.	**Passengers**	**Brief. Instruct to sit upright**
9.	**ELT**	**Set to ON**
	If landing site allows:	
a.	**Landing gear**	**DOWN**
	If landing site not suitable for gear down landing:	
a.	**Landing gear**	**Keep UP**
b.	**Flaps**	**40°**
10.	**Final approach speed**	**88 KIAS for 10450 lb (4740 kg). AOA centered**
	After touch down:	
11.	**MASTER POWER switch**	**EMERGENCY OFF**
	After the aircraft has stopped:	
12.	**Aircraft**	**Evacuate**

Figure 27 - Procedure for a forced landing, with cutoff/feathered engine.
Source: Aircraft AFM/QRH

1.19. Additional information.

In order to provide support for the analysis, and for purposes of comparison, two occurrences are discussed below. Such occurrences involve aircraft that sustained uncontrolled in-flight propeller-feathering or inadvertent loss of the pitch-control capability.

With the same purpose, events related to the ENGINE NP warning light illumination on another Pilatus PC-12 aircraft are presented for consideration.

<u>PR-ARZ, 02Jul2012 - RF IG-126/CENIPA/2013</u>

The aircraft was a CARAVAN C-208 equipped with a PT6A-114/114A engine. It was performing a cruise flight when an inadvertent engine deceleration occurred, followed by a gradual feathering of the propeller, facts that led it to make an emergency landing on a highway.

According to an extract from the Final Report shown below, during a visit of the Maintenance Organization responsible for the occurrence aircraft, the investigation committee learned the following:

> [...] it was found that there was a "culture" of adjusting the Beta Valve clevis in a way that was different from the prescribed in the aircraft Engine Maintenance Manual, leaving the clevis uneven (in this case, ADVANCED) in relation to the front face of the Beta Valve nut. Such procedure, besides being performed without the knowledge of the workshop managers, aimed to meet the request of the pilots, on the grounds that such adjustment would contribute to improving the performance of the CARAVAN aircraft in certain phases of the operation. (RF IG-126/CENIPA/2013).

The adjustment mentioned in the investigation was represented pictorially in the Final Report by means of the Figure 28 below.

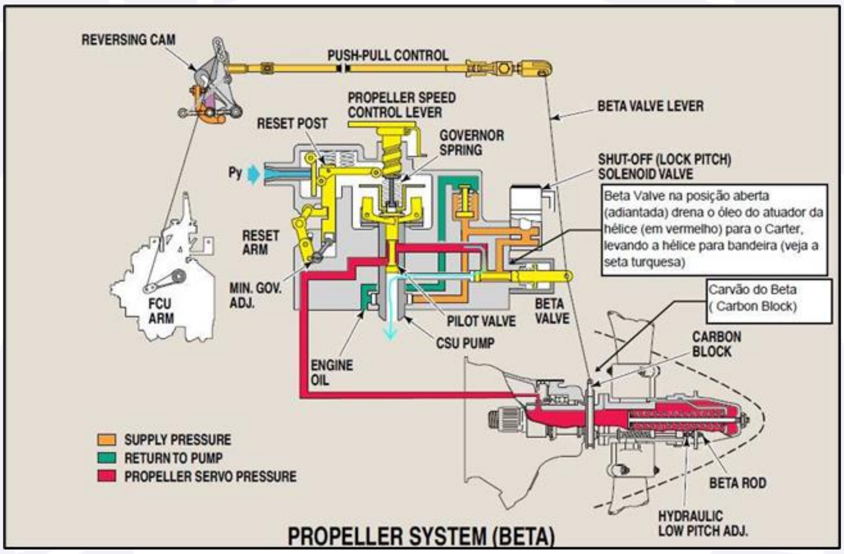


Figure 28 - Pictographic representation of the aircraft pitch control system.

The analysis led to the following conclusions:

> [...] there was an inappropriate uneven adjustment of the Beta Valve clevis (in this case, ADVANCED) in relation to the front face of the Beta Valve nut, associated with the normal progressive wear of the carbon block.
>
> Such non-standard adjustment of the Beta Valve, in disagreement with the engine maintenance manual, is likely to have reduced the tolerance-to-wear of the carbon block, which maintains a frictional contact with the front inner wall of the sliding ring.
>
> The coexistence of these situations (inadequate adjustment of the Beta Valve, together with the normal and progressive wear of the carbon block) may have contributed to the advancement of the Beta Valve to the point of reaching the "opening position" which drains the propeller oil by means of the Governor Pilot Valve, leading to the inadvertent feathering of the propeller.

<u>Comparison with the case of the PC-12, HB-FQF, MSN1354</u>

According to the TM-12-006531 provided by the aircraft manufacturer in support of this investigation, on 26Apr2012, a PC-12/47E aircraft performing a test flight in the production phase experienced severe RPM fluctuations. The event was similar to the one involving the PR-WBV.

The following text was extracted from that document: (in free translation)

> During the phases of taxi, takeoff, and climb, no abnormal indications were observed. Upon aircraft leveling off and acceleration with climb power at 12,000 ft., the propeller RPM dropped from the normal operating range to values between 300 and 500 RPM. A series of PCL positions were tested to try to find out if there was a position where the RPM would remain at acceptable levels. Only when the PCL was moved to the IDLE position did the RPM recover to values between 1600 and 1700 RPM. A decision was made to keep the engine running and proceed with an underpowered approach. The approach with the engine without power was carried out successfully. When trying to perform a backtrack with addition of power for the taxi, the NP again dropped to values close to 700 RPM, whereupon the aircraft was stopped, and the engine was cut off by means of the Condition Lever. -006531, Pilatus, 10.09.2020).

The similarities observed between the event above and the one that involved the PR-WBV, in addition to the un-commanded drop in RPM, refer to the fact that the PCL applications brought together an increase of the torque, fuel flow, and interturbine temperature, without NP response, except for brief moments - which did not represent effective recovery of the propeller pitch-control.

The investigation of the event conducted by the aircraft and engine manufacturers, reached the conclusion that:

> An anomaly in the propeller's Reversing Push-Pull Cable affected its adjustability.

The anomaly was due to damage to the control-assembly front-terminal threads, which resulted in the loss of axial positioning of the cable element. This, in turn, led to disruption of the beta-valve propeller-governor adjustment, which resulted in the propeller transitioning to the “feather” position in the operation at high power.]

Because of such conclusions, P&WC published the Special Instruction (SI) 40-2012(R2) with guidance for the inspection of the Reversing Linkage Push/Pull control assembly of the propeller in all aircraft/engines of the manufacturer in operation on all aircraft/engines present at the time at the manufacturer Pilatus in Switzerland, as well as at its subsidiary in the United States, as well as in its subsidiary in the United States. The serial number of the engine installed on the PR-WBV aircraft was not included in the list of those that had to undergo such inspection.

According to the manufacturer's note, the inspection of the 42 engines included in the list found no anomalies in the inspected components. The origin of the damaged threads could not be determined, and the case was considered an isolated event.

<u>PC-12/47E PP-ARO aircraft</u>

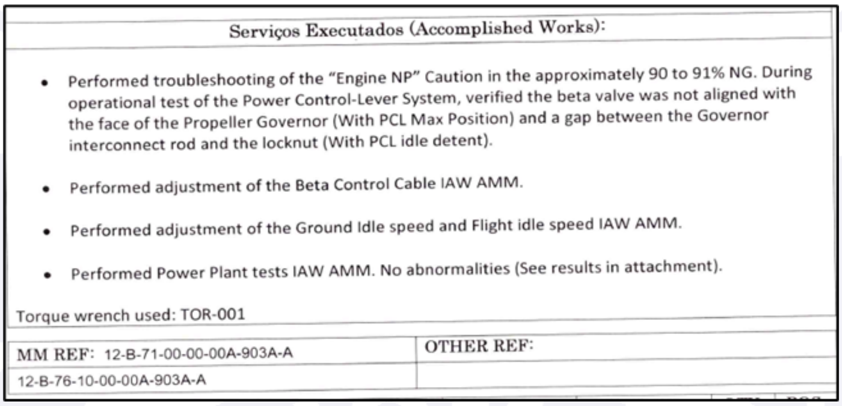
Due to the similarities between the NP fluctuation event that occurred with the PR-WBV, and certain features perceived by the flight crew of PP-ARO, a Pilatus PC-12/47E aircraft equipped with a PT6A-67P engine (SN PCE-RY0324), the investigators sought to obtain information on the event and on the actions taken to solve the problem.

On 13Apr2018, about three weeks before the PR-WBV accident, the PP-ARO aircraft aborted the takeoff after warning of an ENGINE NP, ITT alert, and “High Oil Pressure”. The aircraft was sent to the same Maintenance Organization that serviced the PR-WBV. The referred workshop performed maintenance tasks on the PP-ARO from 24 through 26Apr2018, and released the aircraft for return to operation.

The aircraft returned to the Maintenance Organization in September and October for avionics-related repairs. During checks of the aircraft systems on 10Oct2018, the ENGINE NP warning light illuminated with indication of Gas Generator Rotation Speed (Ng) greater than 90%, although the aircraft had not reached the minimum 1,640 RPM as would be expected. After tests of the Power Plant, the maintenance organization released the aircraft for return to flight.

Due to the recurrence of failures and the critical importance of the events involving the PR-WBV, the operator urged the Maintenance Organization to consult with P&WC and Pilatus Aircraft Ltd., which requested new tests and checks of the engine rigging.

In the maintenance services carried out on 26Oct2018, the workshop found out that there was not alignment between the beta valve and the face of the propeller governor (with the PCL in its max position), in addition to other findings and adjustments made (see Figure 29).



Serviços Executados (Accomplished Works):

- Performed troubleshooting of the "Engine NP" Caution in the approximately 90 to 91% NG. During operational test of the Power Control-Lever System, verified the beta valve was not aligned with the face of the Propeller Governor (With PCL Max Position) and a gap between the Governor interconnect rod and the locknut (With PCL idle detent).
- Performed adjustment of the Beta Control Cable IAW AMM.
- Performed adjustment of the Ground Idle speed and Flight idle speed IAW AMM.
- Performed Power Plant tests IAW AMM. No abnormalities (See results in attachment).

Torque wrench used: TOR-001

MM REF: 12-B-71-00-00-00A-903A-A	OTHER REF:
12-B-76-10-00-00A-903A-A	

Figure 29 - Services performed on the PP-ARO aircraft related to ENGINE NP troubleshooting.

The crew reported that, after the above-mentioned adjustments, the PN started dropping an average of 10 RPM per flight. On 13Dec2018, the aircraft presented a fluctuation in the propeller RPM when reducing or applying power during cruise flight, prompting its return to the Maintenance Organization. After new adjustments monitored by P&WC representatives, and replacement of the governors, the failure did not recur.

1.20. Useful or effective investigation techniques.

NIL.

2. ANALYSIS.

The PR-WBV aircraft was on a private flight from SDAG to SBMT.

The aircraft was within the weight and balance limits specified by the manufacturer. The approximate weight at the time of the accident was 3,983 kg (8,781 lb.).

About six months prior to the accident, a four-blade propeller had been replaced with a five-blade one, as per the CST approved by ANAC. Four months later, due to FOD, the aircraft's engine was replaced with a rental one. Additionally, services related to removal and installation of the propeller, installation of various components, and the balancing of the propeller were listed in the pertinent logbooks.

After installation of the rental engine, the aircraft pilots observed that the ENGINE NP warning light would illuminate with some frequency during phases of ground operation of the aircraft. Such situation motivated them to return the aircraft to the pertinent maintenance organization to sort out the problem. The workshop inspected the powerplant, washed the compressor, and performed a pre-flight. Then, on 10Apr2018, the aircraft was released for return to operation, that is, twenty-one days before the accident.

Even though the failure related to the ENGINE NP warning light illumination was intermittent, and did not recur when the aircraft returned to the workshop responsible for the engine replacement, the investigation of the problem was not sufficient to detect or remedy the problem, since the problem persisted, and even got worse until the accident flight.

As for the day of the occurrence, the pilots reported having performed the appropriate flight planning, done the briefing, and performed the pre-flight inspections. The first leg of the flight was uneventful. According to data extracted from the ACMS and FHDB, the first signs of abnormality started already in SDAG, after the arrival and boarding of passengers.

From engine startup until takeoff roll in SDAG, there were two episodes of propeller-rotation (NP) dropping below 950 RPM, with duration of 20 seconds each one, which would satisfy the conditions for ENGINE NP warning light illumination, but such illumination was not confirmed. The pilots reported that the warning light did illuminate, and that they did not perform the procedures prescribed in the QRH. After analysis, it was not possible to determine whether the rotation had a recovery above 950 RPM because of crew intervention or due to self-stabilization of the system.

Thus, the question remained as to whether the light came on and off during the taxi with the crew continuing the flight, or whether the drop in the RPM was not noticeable to them.

A few moments after the aircraft started the descent, upon reduction of the PCL to the prescribed torque selection, the propeller speed began to drop quickly and gradually, and the ENGINE NP warning light illuminated.

The crew reported having tried to locate the ENGINE NP failure in the physical QRH of the aircraft, but they had difficulty finding it initially. The SIC stated having sought the emergency corresponding to the condition observed by them (in-flight feathering of the propeller). Even though he followed the PIC's guidelines at that time, the very PIC decided to locate the failure reference on his own, and found it shortly afterwards.

The emergency procedure recommended for the situation of ENGINE NP warning light illumination in flight, in cases of propeller-rotation below 1,640 RPM, determined an increase of power by means of the PCL, and an increase of the speed. The crew performed such procedure, but they were unsuccessful in regaining control of the NP. The procedure contained in the manual did not define any further action in case the application of the items did not result in normalization of the propeller rotation, leaving it up to the crew, at that point possibly overloaded with the management of the emergency, the decision of adopting other procedures.

The crew reported not having considered performing actions related to TOTAL POWER LOSS or PARTIAL POWER LOSS, since they had not correlated that situation to a case of engine failure. In addition, they reported that they did not consider the option of shutting down the engine, due to the expected loss of equipment connected to the generator, screens, etc.

The implementation of the procedures recommended for a PARTIAL POWER LOSS emergency deserved consideration, since the manual defined its identification as an “un-commanded reduction of power or absence of response to PCL movements”. However, the movement of the PCL generated a response in terms of Ng, ITT, and TQ that may have confused the pilots.

Considering the feathered propeller, the absence of NP response to the movements of the PCL, and the availability of sufficient altitude AGL, a possible decision would be to select the speed with the best glide ratio. In this manner, the range of the aircraft would increase, making it possible for the crew to have more time to analyze the situation, and enhance their decision-making capability.

By prematurely disconnecting the autopilot, a piece of equipment designed to reduce the pilots’ workload, the crew gave up the ability of a better management of the emergency.

The investigators verified that the best glide speed as a function of the aircraft weight at that moment was not used, something that also related to the fact that the “emergency descent” procedure was not considered. The speed prescribed in the QRH and AFM for the approximate weight of the aircraft in that condition would be close to 110 kt., but the speed numbers maintained throughout the emergency descent were considerably higher.

If such speed had been pursued, it would have been possible to reach the vertical of SDUB runway at a higher altitude AGL, allowing for an adequate configuration of the aircraft and preparation for landing in the location selected.

According to the crew, shortly after perceiving the failure and making the decision of looking for a suitable place for a forced landing attempt, the GPS NEARST function was used, and it indicated the SDUB aerodrome. The crew then decided to proceed to that location, as they considered that SBSJ would be farther away, making it difficult for the aircraft to reach the runway.

The PIC reported that, after the left turn, he had being concerned about whether the altitude AGL they had would be enough to fly over the mountain range. During the descent, there were times when the aircraft entered IMC conditions, until they ended up crossing the cloud layer, between 4,000 ft and 3,000 ft.

The crew reported that , upon overcoming the *Serra do Mar*, they realized that their altitude AGL was still too high for appropriately joining the traffic pattern, which is why they increased their rate of descent, gaining speed. The investigators observed that the hypothesis of preserving the altitude AGL for a controlled “emergency traffic” was not considered, with a possible 360º-turn to lose altitude, taking advantage of the cabin resources to manage the failure and save time for proper aircraft configuration.

The SIC assisted with the calculations to verify whether they would be able to fly over the *Serra do Mar*, and coordinated with the FCA in the region. Emergency was not declared on the frequency of the control agencies.

As for the runway threshold selection, the crew reported having chosen threshold 27 for the landing on account of the 380m backward-displacement of threshold 09, in addition to the fact that they had sufficient altitude AGL. In the same way that shutting down the engine was not considered, neither did the crew discuss the question of the necessary landing distance, or the speed and configuration necessary to ensure a safe landing.

The runway 27 of SDUB had an availability of 940 m for landing. According to the performance charts listed in the AFM, at a speed of 1.3 Vs and flaps at 40º, the total distance required for landing would be less than 700 m, considering an average braking condition and use of IDLE after the touchdown. The calculated stall speed for that condition (flaps at 40º) would be 63 kt., considering a maximum angle-of-bank of 15 degrees on final. Therefore, the ideal speed for such approach would be close to 82 kt.

Even though the pilots reported in the interviews that they stayed calm and serene while managing the emergency, and that there were no personal aspects that could have affected their performance, the investigation committee observed that both of them had difficulty identifying the problem and finding the appropriate procedures in the QRH, evidencing a deficiency in their perception processes. In other words, the information available in the cockpit and the signs sent out by the aircraft itself were not sufficient for an adequate interpretation of the situation and determination of the best ways to find a solution.

In addition to the issues related to perception, one should note that the pilots had experience operating that aircraft in SDUB, always during daytime. That might be the reason why they resorted to the usual procedures stored in their memories for the attempt to land in that scenario despite the different conditions, given the irreversible feathering of the propeller.

As observed in the operational aspects, during the crew's attempts to move the PCL, only for a few moments did the system appear to have recovered the capability to control the propeller pitch, something not perceived by the crew and that did not represent an effective reversal of the ongoing failure.

While measuring the position of the beta ring in the analyses of the propeller components, one verified that the displacement of the ring was beyond the limits specified by the manufacturer. According to the report, it was not possible to identify whether this occurred because of a maintenance action or an event at the assembling of the ring upon propeller replacement. Such discrepancy could also have resulted either from the impact sustained by the propeller blades during the emergency landing or from the process utilized for the removal of the wreckage.

It is noteworthy, however, that the in-flight feathering of the propeller could relate to the adjustment of the beta valve in disagreement of the maintenance manual prescriptions, being in a more advanced position, according to the report produced by the engine manufacturer.

As the pilot began the descent, the engine power was reduced in response to an increase in the aircraft's speed. Then, the propeller governor reacted to change the angle of the blades to a certain position, with the objective of maintaining a constant speed of 1,700 RPM. That was accomplished by draining oil from the interior of the propeller hub, and directing it to the engine crankcase. It is likely that the beta ring moved, something considered normal.

The movement of the beta ring (sliding ring) acts directly on the beta valve, which can increase or reduce the volume of oil flowing to the propeller hub, to keep it at a constant speed. If the beta valve is adjusted in a more advanced position, i.e., closer to the beta ring, it can drain the oil from the propeller and move the blades to the “feathered” position, as verified in the bench test of a propeller-governor similar to the one equipping the occurrence aircraft.

For this reason, even though the tests performed on the components individually did not result in the identification of failures, the subsequent analyses allowed to formulate the hypothesis that the interaction between the propeller-governor and the adjustment of the beta valve led to the occurrence of the event, mainly due to the incorrect adjustment.

As for the electricity tests performed, the investigation committee found that the EPS BUS LH REAR bar was short-circuited. However, further investigation indicated that the possibility that such a condition could have occurred during the flight and triggered the un-commanded feathering was remote. The most likely is that such discontinuity has arisen in consequence of alterations suffered by the airframe and aircraft systems at the impact.

Furthermore, the three cases cited in “**1.19 Additional Information**” have similarity with the PR-WBV event, especially with regard to the adjustment of the beta valve. In the first case, the PR-ARZ, such adjustment was a matter of deliberate action. In the second case, an anomaly led to the disruption of the propeller governor's capability to act in relation to the beta valve.

In the third case, which occurred around the time of the PR-WBV event, one verified that the beta valve was not aligned with the face of the propeller-governor when the PCL was moved to its maximum position. Although each event has its own particularities, all of them related to the coupling of the mentioned components, which proved to be very critical for a possible loss of the ability to control the propeller pitch.

The point of irreversibility of the accident started with the approach profile performed for the landing in SDUB, in function of the speeds and configurations selected by the crew. For the weight of the aircraft during the flight of the occurrence, the manufacturer's procedures recommended a glide speed of approximately 110 kt. and a final approach speed of 82 kt., with the landing gear down and flaps at 40º.

However, the aircraft speed on the base leg was 165 kt., and the landing gear started being lowered at approximately 150 ft. above the runway at a speed of about 150 kt. The flaps started being lowered at approximately 120 ft. The aircraft passed over the threshold at a speed of 116 kt., with the landing gear down, and flaps at 16º (still in motion). Under such conditions, landing and stopping the aircraft within the limits of the runway in SDUB would not be possible when one considers the landing distance available.

In relation to the SIC, since the aircraft had a "CLASS" category bestowed by the regulatory agency, there was no requirement for simulator training or other types of aircraft-specific training options. In such situation, it was possible to perceive the little familiarization of the crewmember with emergencies and abnormal situations, a fact that may have prevented him from providing better assistance to the PIC in the management of the situation.

In the case of the PIC, on the other hand, even though he had performed both ground and simulator training, only the latter contemplated the Maximum-Rate Descent, without dealing with a Maximum-Range situation. Anyway, the practice training covered the situation of emergency landing with the engine inoperative.

Concerning the above considerations, it is worth highlighting that better crew qualification and training, especially by means of flights in the simulator (available at the time of the occurrence, as required by the regulatory agency) could have contributed to enhance their operational performance under the circumstances, in the management of the emergency condition and the emergency traffic profile for landing. At any rate, the aircraft has a reasonable degree of complexity and passenger transport capacity, which can justify the hypothesis of more demanding training requirements.

3. CONCLUSIONS.

3.1. Findings.

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

b) the PIC held valid Single-Engine Land Airplane (MNTE) and Airplane IFR Flight (IFRA) ratings;

c) the SIC held valid Single-Engine Land-Airplane (MNTE) and Multi-Engine Land-Airplane (MLTE) ratings;

d) the pilots had qualification and experience in the type of flight;

e) the aircraft had a valid Airworthiness Certificate (CA);

f) the aircraft was within the prescribed weight and balance limits;

g) the records of the airframe, engine, and propeller logbooks were up to date;

h) the meteorological conditions were compatible with the conduction of the flight;

i) on 02Oct2017, a modification was made in the approved type-aircraft project;

j) on 06Mar2018, the engine of the aircraft was replaced with a rental engine, on account of damage caused by FOD;

k) the aircraft returned to the maintenance organization responsible for the engine replacement, due to recurrent episodes of Engine NP Warning Light illumination;

l) the maintenance organization inspected the powerplant, washed the compressor, and performed a pre-flight, after which the aircraft returned to operation;

m) the aircraft took off from SDAG, bound for SBMT;

n) between engine start-up and takeoff from SDAG, there were two drops of the propeller rotation (NP) to values below 950 RPM;

o) after taking off from SDAG, the aircraft climbed to, and maintained, FL145;

p) moments after the aircraft started descent, and upon reduction of the PCL, the propeller rotation began to drop quickly and continuously;

q) the adoption of the procedures prescribed for the *situation "ENGINE NP - In flight, If propeller is below 1640"* had no effect;

r) the NP dropped to a minimum value of 266 RPM;

s) the crew decision was to land in SDUB;

t) after the touchdown, a maneuver was performed aiming at exchanging speed for altitude, and deviation of the aircraft to a swampy area located in the left-hand side of the overshoot area;

u) in the functional tests of the engine performed after the occurrence, one verified normal operating conditions and full response to control demands;

v) upon examination of the propeller, and measurement of the beta ring distance, one verified that the ring displacement was outside the limits specified by the manufacturer;

w) it was not possible to identify whether such discrepancy had resulted from a maintenance procedure or from the impact during the emergency landing;

x) analysis of the propeller-governor revealed that the internal components were in operating condition;

y) the aircraft sustained substantial damage, and

z) the PIC suffered serious injuries, the SIC and two of the passengers were slightly injured, while the other six passengers were not hurt.

3.2. Contributing factors.

- **Training – undetermined.**

Even though the PIC had undergone simulator training less than a year before the occurrence, his difficulty perceiving the characteristics of the emergency experienced in order to frame it in accordance with his simulated practice suggests deficiencies in the processes related to qualification and training.

The SIC, in turn, was not required to undergo that type of training, since the occurrence airplane had a Class-aircraft classification bestowed by the regulatory agency. The training and qualification process available to him in face of the circumstances may have contributed to his lack of ability to recognize and participate in the management of the failure with due proficiency, when one also considers the selection of procedures and his assisting role in relation to the speeds and configuration of the aircraft.

- **Instruction – a contributor.**

As for the SIC, considering the fact that the aircraft classification did not require simulator sessions or other types of specific training, it was possible to note that he was not sufficiently familiar with emergencies and abnormal situations, something that prevented him from giving a better contribution to the management of the situation.

- **Piloting judgment – a contributor.**

There was inadequate assessment of the flight parameters on the final approach, something that made the landing in SDUB unfeasible, when one considers the 940 meters of available runway.

- **Aircraft maintenance – undetermined.**

During the measurement of the distance of the beta ring performed in the analysis of the propeller components, one verified that the displacement of the ring was outside the limits specified by the manufacturer. It was not possible to identify whether such displacement was due to a maintenance action or the result of a ring-assembly event at the time of propeller replacement. However, such discrepancy may have resulted from the impact of the propeller blades during the emergency landing.

Furthermore, the aircraft was subject to inspection of the failure related to the ENGINE NP warning light illumination prior to the accident. Given the fact that such illumination was intermittent, and the investigation could not identify the reasons for the warning, the aircraft was released for return to flight without in-depth investigation as to the root cause and possible implications of a failure related to the inadvertent drop in RPM.

- **Memory – undetermined.**

Although the PIC had undergone training in a class D aircraft-simulator certified by the manufacturer, it was not possible to verify the necessary association between the trained procedures and his performance in joining the traffic pattern and landing with a powerless aircraft in emergency. Furthermore, since the PIC frequently landed in the location selected for the emergency landing attempt, it is likely that he sought to match such emergency approach with those normally performed, in which he could count both on the “aerodynamic brake” condition with the propeller at IDLE and on the use of the reverse.

- **Perception – a contributor / undetermined.**

There was not adequate recognition, organization and understanding of the stimuli related to the condition of propeller feathering, which led to a lowering of the crew’s situational awareness.

Such reduction of the situational awareness made it difficult to assess the conditions under which the emergency could be managed, as the crew settled on the idea of landing in SDUB, without observing the condition of the airfield, meteorology, distance necessary for landing without control the engine, best glide speed, approach, and aircraft configuration.

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

Since the first decisions made for identification of the emergency condition, it was not possible to verify the existence of a well-structured decision-making process contemplating appropriate assessment of the scenario and available alternatives. Objective aspects related to the SDUB runway, such as runway length and obstacles, the actual condition of the aircraft at that time, or contingencies, were not considered.

- **Support systems – a contributor.**

The Aircraft Manual and the QRH did not clearly contemplate the possibility of propeller feathering in flight, making it difficult for the pilots to identify the abnormal condition, and making it impossible for them to adopt appropriate and sufficient procedures for the correct management of the emergency.

Considering the possibility that the application of the “ENGINE NP - In Flight” emergency procedure prescribed by the QRH would not achieve the desired effect, there were no further instructions as to the next actions to be taken, leaving to the crew a possible interpretation and selection of another procedure of the same publication.

- **Managerial oversight – undetermined.**

As for the maintenance workshop responsible for the tasks of engine replacement, together with adjustment of the propeller and its components: in the inspection at the request of the pilots after an event of ENGINE NP warning light illumination, the maintenance staff released the aircraft for return to operation. The investigation committee raised the possibility that the supervision of the services performed, by allowing the release of the aircraft, was not sufficient to guarantee mitigation of the risks related to the aircraft operation with the possibility of an intermittent recurrence of the failure.

4. SAFETY RECOMMENDATIONS

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 consonance with the Law n°7565/1986, recommendations are made solely for the benefit of 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".

To Brazil's National Civil Aviation Agency (ANAC):

A-080/CENIPA/2018 - 01 **Issued on 08/15/2023**

Work with Pilatus Aircraft Ltd., with the purpose of assessing the sufficiency of publications concerning PC-12 aircraft, especially with regard to the procedures related to the "ENGINE NP - In flight" warning, when the propeller RPM does not correspond to the movement of the PCL, and is below 1,640 RPM.

A-080/CENIPA/2018 - 02 **Issued on 08/15/2023**

Work with *Synerjet do Brasil* Maintenance Organization in order to ensure both compliance of the company's processes with approved maintenance requirements, and effectiveness of their processes of supervision on the tasks performed.

A-080/CENIPA/2018 - 03 **Issued on 08/15/2023**

Evaluate the need to include PC-12 aircraft in the table of CLASS aircraft models that require specific endorsement, with the purpose of ensuring compliance with the minimum rating and training requirements for pilots to be qualified to operate such equipment.

5. CORRECTIVE OR PREVENTATIVE ACTION ALREADY TAKEN.

NIL.

On august 15th, 2023.