COMANDO DA AERONÁUTICA

CENTRO DE INVESTIGAÇÃO E PREVENÇÃO DE ACIDENTES AERONÁUTICOS

FINAL REPORT
A-104/CENIPA/2021

OCCURRENCE:	**ACCIDENT**
AIRCRAFT:	**PS-CSM**
MODEL:	**B200GT**
DATE:	**14SET2021**

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 14 September 2021 accident involving the model B200GT aircraft of registration marks PS-CSM. The occurrence was typified as “[LOC-I] Loss of control in flight”.

At approximately 11:35 UTC, shortly after taking off from SDPW (Aerodrome of *Piracicaba*, State of *São Paulo*) on a private flight with 07 POB (02 crew and 05 passengers), the aircraft crashed into the ground in an area of vegetation operating 1,374 pounds above maximum published Takeoff Gross Weight. The stall warning occurred shortly after takeoff.

Investigators found that one of the engines propeller speed increased above normal setting during takeoff. Subsequently, the propeller of the right-hand engine coarsened the blade angle towards the feather position, followed by loss of control of the aircraft.

The aircraft was destroyed in the crash.

The two pilots and the five passengers suffered fatal injuries.

Being the USA the State of aircraft design and manufacture, the USA’s NTSB (National Transportation Safety Board) appointed an Accredited Representative for participation in the investigation of the accident. The Canadian TSB (Transportation Safety Board of Canada) also designated an Accredited Representative, as Canada was the State of engine design.

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GLOSSARY OF TECHNICAL TERMS AND ABBREVIATIONS

AFM	Aircraft Flight Manual
ANAC	Brazil's National Civil Aviation Agency
ASDA	Accelerate-Stop Distance Available
CANAC	ANAC Code
CAS	Crew Alert System
CTAC	Civil Aviation Training Center
CAVOK	Ceiling And Visibility Ok - no clouds below 5,000 ft. or below the minimum height of the highest sector (whichever the higher), and horizontal visibility greater than 10 km; absence of CBs or significant weather condition for aviation.
CENIPA	Brazil's Aeronautical Accidents Investigation and Prevention Center
CFTV	Closed Circuit TV - Residential Surveillance System
CIV	Pilot Logbook
CMA	Aeronautical Medical Certificate
CRM	Crew Resource Management
STC	Supplemental Type Certificate
CSU	*Constant* Speed Unit
CVA	Airworthiness-Verification Certificate
CVR	Cockpit Voice Recorder
DLA	Delay message
EICAS	Engine Indication and Crew Alert System
FAA	USA's Federal Aviation Administration
FSTD	Flight Simulation Training Devices
IFRA	IFR Flight Rating - Airplane
IS	Supplementary Instruction
ITT	Inter Turbine Temperature
KIAS	Knots-Indicated Air Speed
LABDATA	Cenipa's Flight Recorders' Data Readout and Analysis Laboratory
LDA	Landing Distance Available
METAR	Routine Meteorological Aerodrome Report
MLTE	Multi-Engine Land Airplane Class Rating
MNTE	Single-Engine Land Airplane Class Rating
MTOW	Maximum Takeoff Weight
N1	Rotational speed of the low pressure engine spool
N2	Rotational speed of the high pressure turbine and compressor spool
NM	Nautical Miles
NTSB	USA's National Transportation Safety Board

OM	Maintenance Organization
OSG	Overspeed Governors
PBN	Performance-Based Navigation
PCM	Commercial Pilot License - Airplane
PF	Pilot Flying
PFD	Primary Flight Display
PIC	Pilot In Command
PLA	Airline Transport Pilot License - Airplane
PMD	Maximum Takeoff Weight
PN	Part Number
PPR	Private Pilot License - Airplane
QAV-1	Aviation Kerosene
QRH	Quick Reference Handbook
RBAC	Brazilian Civil Aviation Regulation
ROTAER	Air Routes Auxiliary Manual
RPM	Revolutions Per Minute
RVSM	Reduced Vertical Separation Minima
RWY	Runway
SAFO	Safety Alert for Operators
SBJD	ICAO location designator - *Comandante Rolim Adolfo Amaro* Aerodrome, *Jundiaí*, State of *São Paulo*
SDAM	ICAO location designator - *Campos dos Amarais - Prefeito Francisco Amaral* - State-Aerodrome, *Campinas*, State of *São Paulo*
SERIPA IV	4th Regional Service for the Investigation and Prevention of Aeronautical Accidents
SHP	Shaft Horsepower
SI2F	ICAO location designator - *Fazenda Tarumã* Private Aerodrome, *Santa Maria das Barreiras*, State of *Pará*
SIPAER	Brazil’s Aeronautical Accidents Investigation and Prevention System
SN	Serial Number
SPDW	ICAO location designator - Aeródromo de *Piracicaba*, State of *São Paulo*
SSZO	ICAO location designator - *Santa Marta I* Aerodrome, *Santa Maria das Barreiras*, State of *Pará*
TAWS+	Terrain Awareness Warning System Plus
TODA	Take-Off Distance Available
TORA	Take-Off Run Available
TPP	Private Air Services Aircraft Registration Category
TSB	Transportation Safety Board of Canada
UTC	Universal Time Coordinated
VFR	Visual Flight Rules
V_{MCA}	Air Minimum Control Speed

1. FACTUAL INFORMATION.

Aircraft	**Model:** B200GT **Registration:** PS-CSM **Manufacturer:** *Textron Aviation*	**Operator:** *CSM Agropecuária Ltda*.
Occurrence	**Date/time**: 14SET2021 – 11:35 (UTC) **Location:** Area of vegetation near SDPW. **Lat.** 22°41'33"S **Long.** 047°37'27"W **Municipality – State:** *Piracicaba - São Paulo*.	**Type(s):** [LOC-I] Loss of control - inflight

1.1. History of the flight.

At approximately 11:35 UTC, the aircraft took off from SDPW (Aerodrome of *Piracicaba*, State of *São Paulo*), bound for SI2F (*Fazenda Tarumã* Aerodrome, *Santa Maria das Barreiras*, State of *Pará*), on a private passenger transport flight, with two crew and five passengers on board.

After takeoff, the aircraft crashed into the ground in an area of vegetation.

The aircraft was destroyed in the crash.

The aircraft occupants suffered fatal injuries.

1.2. Injuries to persons.

Injuries	Crew	Passengers	Others
Fatal	2	5	-
Serious	-	-	-
Minor	-	-	-
None	-	-	-

1.3. Damage to the aircraft.

The aircraft was destroyed.

1.4. Other damage.

NIL.

1.5. Personnel information.

1.5.1. Crew's flight experience.

Flight Experience		
	PIC	SIC
Total	8.366:06	504:17
Total in the last 30 days	00:46	00:46
Total in the last 24 hours	00:22	00:22
In this type of aircraft	297:14	85:30
In this type in the last 30 days	00:46	00:46
In this type in the last 24 hours	00:22	00:22

RMK: Flight experience data obtained from the pilots' CIV (digital Pilot Logbook), as well as from the records of the recovered aircraft logbook.

As for the PIC (Pilot in Command), the flight hours declared by the companies for which he worked as a pilot were added to his flight experience, since they had not been included in his digital CIV.

For both pilots, the flight time recorded in the Cockpit Voice Recorder (CVR) in the 24 hours prior to the accident was also considered**.**

1.5.2. Personnel training.

The PIC did his PPR course (Private Pilot - Airplane) in 1999, at Training Division - *Escola de Pilotagem Ltda,* in *Piracicaba*, State of *São Paulo*. The corresponding license was issued in February 2001. In 2002, he earned his PCM license (Commercial Pilot - Airplane) and, in 2010, his PLA license (Airline Transport Pilot - Airplane).

The pilot in the right seat, throughout this final report referred to as 2P*, completed the PPR course at *Escola de Aviação* Sierra Bravo, in *Americana*, State of *São Paulo*, between 2016 and 2017. In 2018, he earned his PCM license.

1.5.3. Category of licenses and validity of certificates.

The PIC held a PLA license, and valid ratings for MLTE (Multi-Engine Land Aeroplane) and IFRA (Instrument Flight - Airplane).

The 2P* held a PCM license and valid ratings for MLTE and IFRA.

1.5.4. Qualification and flight experience.

Although the PIC's digital CIV was not up to date, the hours recorded by the companies where he worked as a pilot totaled approximately 7,872 hours, 4,185 of which in the condition of Pilot in Command. Thus, his overall total reached 8,366 flight hours.

The PIC's operational experience began in 2002, as a co-pilot of multi-engine aircraft for an air taxi company. In 2005, he became a captain in that company, a position he held until January 2008.

In November 2008, he began operating aircraft such as PA-32 (MNTE), PA-31 and PA-34 (MLTE) for another air taxi company based in *Salvador*, State of *Bahia*.

In 2009, the PIC completed Ground School on the King-Air BE-20 aircraft at *Escola de Pilotagem Manche* in the city of *Salvador*, State of *Bahia*.

In 2011, at a new air taxi company, the PIC began operating BE90, LR55, C525, C510 and E110 aircraft.

He underwent a proficiency check ride to earn his BE20 type rating in June 2012.

In the interval between 2013 and 2015, he did not operate any BE20 aircraft, as his rating had expired. In August 2015, he performed a local retraining flight and three en route retraining flights in a BE20 type aircraft. Records from the ANAC (Brazil's National Civil Aviation Agency) showed that his BE20 type rating had been renewed in September 2015, with a one-year validity.

This type rating allowed him to operate B200GT aircraft, such as the PS-CSM. Nonetheless, from 2016 onward, in accordance with the ANAC's Supplemental Instruction n° 61-004G ("List of ratings endorsed by the ANAC in pilot licenses"), aircraft with Maximum Take-Off Weight (MTOW) equal to or less than 5,670 kg, which could be operated by a single pilot and which did not have turbojet/turbofan engines, would require an MLTE Class rating. That was the reason why the PIC's BE20 type rating expired in September 2016.

On the occasion, since the PIC held a BE20 type rating, he was under the transition rule set forth in the IS 61-006 - "Procedures for the Entry of Endorsements in Pilot Flight Records", Revision A, published on 20 April 2016, which established the following:

> Transition rule
>
> Pilots whose type ratings have been converted to class ratings upon Amendment 06 to RBAC n° 61 <u>are considered endorsed on all aircraft models that they have already flown under that type rating (for more details, see Appendix C to this IS)</u> (emphasis added).

After the transition provided for by the IS 61-006, the PIC maintained the MLTE Class rating, having performed his latest revalidation on 31 October 2020 on a PA-34 model aircraft, which is a twin-engine reciprocating powered airplane.

In 2019, he also took a simulator session for the training of differences of the Super King Air B250 aircraft at Flight Safety International, prior to the ferry flight of the PS-CSM aircraft from the United States to Brazil.

Based on the records contained in the recovered aircraft-logbook, one found that the PIC operated the PS-CSM aircraft several times in the ninety days prior to the accident. Therefore, he also met the criteria established in Section 21, Amendment n° 13, Subpart A, of the Brazilian Civil Aviation Regulation n° 61 (RBAC-61) - "Licenses, Ratings and Certificates for Pilots", concerning his recent experience.

One, therefore, considered that the PIC was qualified, according to the requirements established by the ANAC, and that he had experience in the type of flight.

With regard to the qualification of the 2P*, one found that he had not obtained the qualification for the BE20 type, prior to the transition provided for by the IS 61-004G. In this case, in order to qualify to operate B200GT aircraft, in addition to holding the MLTE Class rating, he would have to receive endorsement, as established in section 61.199 of the RBAC-61:

> 61.199 Privileges and limitations of the holder of a category and class rating
>
> (a) Subject to compliance with the provisions established in this Regulation, the prerogatives of the holder of a category or class rating are to fly aircraft of the category or class for which they are qualified, as pilot in command or second in command.
>
> (b) The holder of a category or class rating may exercise their prerogatives in all aircraft models belonging to the category or class for which they are qualified.
>
> (1) <u>Notwithstanding the provisions of the caput, the ANAC may establish, by means of a Supplementary Instruction, the requirement of minimum training and endorsement in the CIV to operate specific aircraft models. In these cases, the exercise of the prerogatives of the holder of a category or class rating is subject to the prior completion of training and obtainment of the endorsement.</u> (emphasis added)

In accordance with the IS 61-006, revision H, in effect at the time the 2P* earned his qualifications, Beechcraft 200 Series aircraft certified with MTOW equal to or less than 5,670 kg required a specific endorsement for pilot qualification (Figure 1).

Data de emissão: 13 de novembro de 2020 IS nº 61-006
Data de vigência: 1º de dezembro de 2020 Revisão H

APÊNDICE B - TABELAS DE MODELOS DE AERONAVE CLASSE QUE REQUEREM ENDOSSO ESPECÍFICO

CLASSE AVIÕES MULTIMOTORES A TURBINA					
(1) FABRICANTE	(2) MODELO	(3) DESIGNATIVOS PARA FINS DO EXAME PREVISTO EM 61.199(b)(2)	(4) INSTRUÇÃO REQUERIDA PARA O ENDOSSO	(5) QUALIFICAÇÃO MÍNIMA DO PILOTO ENDOSSANTE	(6) OBSERVAÇÕES ADICIONAIS
Asta GAF	Nomad-22B Nomad-24A	A22T	A critério	PC	
Beechcraft/ Raytheon	Beechcraft 90 Series	BE90/BE99/BE10/ BE20	A critério	PC	
	Beechcraft 99 Series		A critério	PC	
	Beechcraft 100 Series		A critério	PC	
	Beechcraft 200 Series - apenas modelos certificados com MTOW igual ou inferior a 5670kg (12500lbs).		A critério.	PC	

Figure 1 - Extract from Appendix B to the IS 61-006H.

Furthermore, according to Appendix B to the IS 61-006H, the minimum qualification for the endorsing pilot was that of Commercial Pilot (PC), and the instruction required for the endorsement was indicated as “At discretion”. For these cases, the IS established the following:

> C5.4.1. Column 4 indicates the training required prior to granting the endorsement. If this column indicates an “At discretion” instruction, the endorsing pilot must provide ground and flight instructions sufficient to enable the endorsed pilot to demonstrate full knowledge and proficiency in the following areas:
>
> a) aircraft structure, systems and limitations;
>
> b) pre-flight procedures, including weight and balance, and verification of general airworthiness conditions;
>
> c) normal ground and flight procedures;
>
> d) abnormal and emergency procedures on the ground and in flight; and
>
> e) procedures in the event of equipment and engine failure.
>
> C5.4.2. In all cases, if there is a published operational assessment for the aircraft model, such assessment should be used as a reference for the training provided. The Operational Assessments can be found on the page http://www.anac.gov.br/assuntos/setorregulado/profissionais-da-aviacao-civil/avaliacao-operacional.

Upon meeting the requirements for a specific Class aircraft model endorsement, the endorsing pilot should log such condition on the digital CIV or make the following declaration on the physical CIV:

> I declare that I have given ground and flight instruction to pilot (Name of endorsed pilot, CANAC of endorsed pilot) in an (model of aircraft, as per designations in Appendix B of the IS n° 61-006) and that I consider him/her proficient to act as pilot in command on aircraft of that model. (Name, CANAC, signature of instructor and name of school/aero club if applicable).

The latest records in the PIC's and 2P*'s digital CIVs referred to flights dated October 2020 and February 2021, respectively. However, in the 2P*'s digital CIV, several records of flights in the PS-CSM aircraft had a “draft” status until July 2021, since the system did not accept such records due to the fact that the 2P* did not have an endorsement for the referred aircraft.

According to the 2P*'s CIV records, one found that he performed a proficiency check ride to revalidate his MLTE rating in February 2021 in a PA-34 aircraft.

Since the Investigation Committee did not identify any endorsement records for the 2P*, he was considered not qualified to operate the PS-CSM aircraft.

1.5.5. Validity of medical certificate.

The pilots had valid Aeronautical Medical Certificates (CMA).

1.6. Aircraft information.

The serial number BY-364 aircraft was a product manufactured by Textron Aviation in 2019 and registered in the Private Air Services Registration Category (TPP).

The aircraft had a valid CVA (Airworthiness Verification Certificate).

The records of the airframe, engine, and propeller logbooks were up to date.

It was a twin-engine turboprop, low wing, “T” tail airplane built entirely of metal, and possessing full cantilever wings.

According to the Major Repairs and Alterations Control Chart, the aircraft had received four modifications by means of Supplemental Type Certificates (STC) related to its performance, to the addition of winglets on the wings, and to the replacement of the metal propellers with structural composite propellers (Figure 2).

Registro	Data	Descrição
SA3366NM (CST 9805-05) PC-4	20/09/2019	RAISBECK RAM AIR INSTALLATION
SA01615SE (CST 2008S04-04) PC-4	20/09/2019	BLR WINGLET INSTALLATION
SA02130SE (CST 2011S10-02) PC-4	20/09/2019	BLR HARTZELL COMPOSITE PROPELLER
SA02131SE (CST 2011S10-05) PC-4	20/09/2019	BLR ULTIMATE PERFORMANCE PACKAGE

Figure 2 - Supplemental Type Certificates applied to the PS-CSM aircraft.

On 25 November 2019, when the PS-CSM had 36 hours and 30 minutes of total flight time, the aircraft was received by *TAM Aviação Executiva e Táxi Aéreo S/A* Maintenance Organization in *Jundiaí*, State of *São Paulo* for a “50-hour” inspection. On the occasion, it underwent interventions because of abnormal increase of the Propeller RPM (N2) upon activation of the automatic feathering system.

On 19 April 2021, with a flight time of 227 hours and 6 minutes, the aircraft was received by the same OM for programmed inspections, when several inspection cards were accomplished, including the “6-month” lubrication of the propellers.

The lubrication of the right-hand propeller was carried out by the referred *TAM Aviação Executiva e Táxi Aéreo S/A* maintenance organization, but during the lubrication of the left-hand propeller, two lubrication screws of this latter propeller were found to be broken.

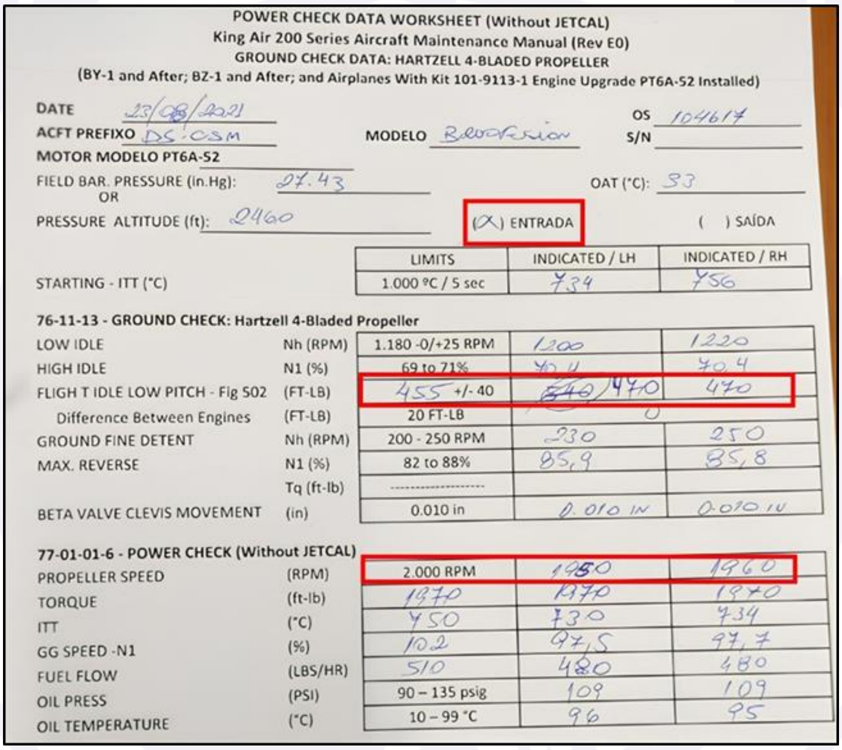
On 23 April 2021, the left-hand propeller (PN HC-E4N-3A, SN NR511) with 227 hours and 6 minutes of operation, was removed by the said maintenance organization and sent for external repair.

On the premises of *Diamond Aviação Ltda*. maintenance organization, the left-hand propeller was partially disassembled, with repairs being performed on the lubrication holes (grease fittings) in slots 2 and 3 of the hub, together with replacement of O-rings, greasing, static balancing, and angle adjustment. After returning from the external workshop, the left propeller was installed, and its dynamic balancing was performed by *TAM Aviação Executiva e Táxi Aéreo S/A* maintenance organization on 25 May 2021.

On 26 May 2021, the Beta Valve Carbon Blocks of the right- and left-hand propellers were replaced, and the engines were checked on the ground, being such services completed on 27 May 2021. It was observed that the logbook of the PN HC-E4N-3A, SN NR511 propeller had a record concerning its removal for repair at an external workshop, but the reinstallation had not been logged. The aircraft's latest comprehensive inspection ("365-day/obtainment of CVA" type) began on 23 August 2021 and was completed on 13 September 2021 on the premises of *TAM Aviação Executiva e Taxi Aéreo S/A*, with the aircraft having 268 hours and 36 minutes of flight time.

On the occasion, the aircraft's engines underwent the "200-hour and 600-hour/12-month" inspection, in addition to desalination wash. The "400-hour/12-month" inspection was performed, as well as the lubrication and RPM adjustment of both propellers maximum RPM trying to attain 2,000 RPM, considering that, during engine rotation, one found that the propellers were rotating below the speed specified in the manual (limited to 1,950 RPM).

The flight idle low pitch adjustment of the left-hand engine was also carried out, since, during engine rotation, one found that it was above the speed allowed in the manual. Figures 3 and 4 show, respectively, the recorded values of propeller RPM and flight idle low pitch of the left-hand engine during the initial check and after adjustments.


POWER CHECK DATA WORKSHEET (Without JETCAL)
King Air 200 Series Aircraft Maintenance Manual (Rev E0)
GROUND CHECK DATA: HARTZELL 4-BLADED PROPELLER
(BY-1 and After; BZ-1 and After; and Airplanes With Kit 101-9113-1 Engine Upgrade PT6A-52 Installed)

DATE 23/08/2021 OS 104617
ACFT PREFIXO DS-CSM MODELO [illegible] S/N
MOTOR MODELO PT6A-52
FIELD BAR. PRESSURE (in.Hg): 27.43 OAT (°C): 33
OR
PRESSURE ALTITUDE (ft): 2460 (X) ENTRADA ( ) SAÍDA

		LIMITS	INDICATED / LH	INDICATED / RH
STARTING - ITT (°C)		1.000 °C / 5 sec	734	756

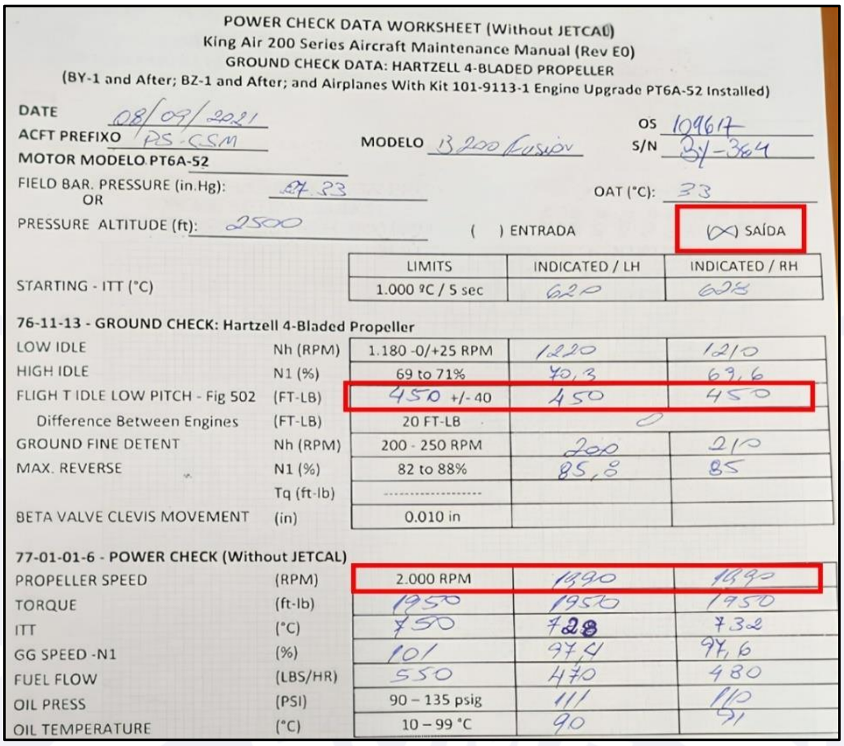
76-11-13 - GROUND CHECK: Hartzell 4-Bladed Propeller

LOW IDLE	Nh (RPM)	1.180 -0/+25 RPM	1200	1220
HIGH IDLE	N1 (%)	69 to 71%	70,4	70,4
FLIGH T IDLE LOW PITCH - Fig 502	(FT-LB)	455 +/- 40	~~540~~ 470	470
Difference Between Engines	(FT-LB)	20 FT-LB	0	
GROUND FINE DETENT	Nh (RPM)	200 - 250 RPM	230	250
MAX. REVERSE	N1 (%)	82 to 88%	85,9	85,8
	Tq (ft-lb)	------------------		
BETA VALVE CLEVIS MOVEMENT	(in)	0.010 in	0.010 IN	0.010 IN

77-01-01-6 - POWER CHECK (Without JETCAL)

PROPELLER SPEED	(RPM)	2.000 RPM	1950	1960
TORQUE	(ft-lb)	1970	1970	1970
ITT	(°C)	750	730	734
GG SPEED -N1	(%)	102	97,5	97,7
FUEL FLOW	(LBS/HR)	510	480	480
OIL PRESS	(PSI)	90 – 135 psig	109	109
OIL TEMPERATURE	(°C)	10 – 99 °C	96	95

Figure 3 - Engine-check sheet at the time of receipt of the aircraft by the OM.



POWER CHECK DATA WORKSHEET (Without JETCAL)
King Air 200 Series Aircraft Maintenance Manual (Rev E0)
GROUND CHECK DATA: HARTZELL 4-BLADED PROPELLER
(BY-1 and After; BZ-1 and After; and Airplanes With Kit 101-9113-1 Engine Upgrade PT6A-52 Installed)

DATE 08/09/2021
ACFT PREFIXO PS-CSM MODELO B200 Fusión OS 109617
MOTOR MODELO PT6A-52 S/N BY-364
FIELD BAR. PRESSURE (in.Hg): 27.33 OAT (°C): 33
OR
PRESSURE ALTITUDE (ft): 2500 ( ) ENTRADA (X) SAÍDA

		LIMITS	INDICATED / LH	INDICATED / RH
STARTING - ITT (°C)		1.000 ºC / 5 sec	620	628

76-11-13 - GROUND CHECK: Hartzell 4-Bladed Propeller

LOW IDLE	Nh (RPM)	1.180 -0/+25 RPM	1220	1210
HIGH IDLE	N1 (%)	69 to 71%	70,3	69,6
FLIGH T IDLE LOW PITCH - Fig 502	(FT-LB)	450 +/- 40	450	450
Difference Between Engines	(FT-LB)	20 FT-LB	0	
GROUND FINE DETENT	Nh (RPM)	200 - 250 RPM	200	210
MAX. REVERSE	N1 (%)	82 to 88%	85,8	85
	Tq (ft-lb)	------------------		
BETA VALVE CLEVIS MOVEMENT	(in)	0.010 in		

77-01-01-6 - POWER CHECK (Without JETCAL)

PROPELLER SPEED	(RPM)	2.000 RPM	1890	1890
TORQUE	(ft-lb)	1950	1950	1950
ITT	(°C)	750	728	732
GG SPEED -N1	(%)	101	97,4	97,6
FUEL FLOW	(LBS/HR)	550	470	480
OIL PRESS	(PSI)	90 – 135 psig	111	110
OIL TEMPERATURE	(°C)	10 – 99 °C	90	91

Figure 4 - Engine-check sheet after the adjustments were made.

As observed in Figures 3 and 4, both the entry and exit sheets contained erasures in the notes of the parameters checked, indicating differences in relation to what had been entered in the Service Order corresponding to the maintenance.

The aircraft had approximately 269 total flight hours on the occasion of the accident.

Flight Controls and Operating Mechanisms

The aircraft was equipped with conventional ailerons, rudder and elevator flight controls. The elevator was connected to the horizontal stabilizer at the top of the "T" tail. Dual controls allowed operation from both pilot stations. There was trim control for the elevator, pedals, and ailerons on the central pedestal of the cabin, with a position indicator for each of the controls.

For elevator trimming, there were both a manual system and an electric one, installed in conjunction with the autopilot system. To assist in directional control, there was the Rudder Boost system and the Yaw Damper. The latter was an integral part of the automatic piloting system.

Rudder Boost

The Rudder Boost system was designed to help the pilot maintain directional control in cases where one of the engines failed or there was a significant variation of power between them.

To this end, the system had two pneumatic servo actuators that acted on the rudder cables to help compensate for any power asymmetry.

The system was activated manually by means of the RUDDER BOOST switch located on the central pedestal.

According to the manual and checklist of the equipment, the system ought to be activated before every flight, and its operation had to be confirmed during the check of the engines.

The aircraft operating manual described that the purpose of the system was to assist in asymmetric conditions, but the pilot had to perform the appropriate trimming.

Propulsion System (PT6A-52 Engine)

The PS-CSM was equipped with two Pratt & Whitney Canada Corp. PT6A-52 turboprop engines, each one featuring a nominal power of 850 SHP.

Each engine had a three-stage axial compressor, a single-stage centrifugal compressor, and a single-stage compressor turbine.

The power turbine, which was a two-stage turbine counter-rotating relatively to the compressor turbine, drove the output shaft.

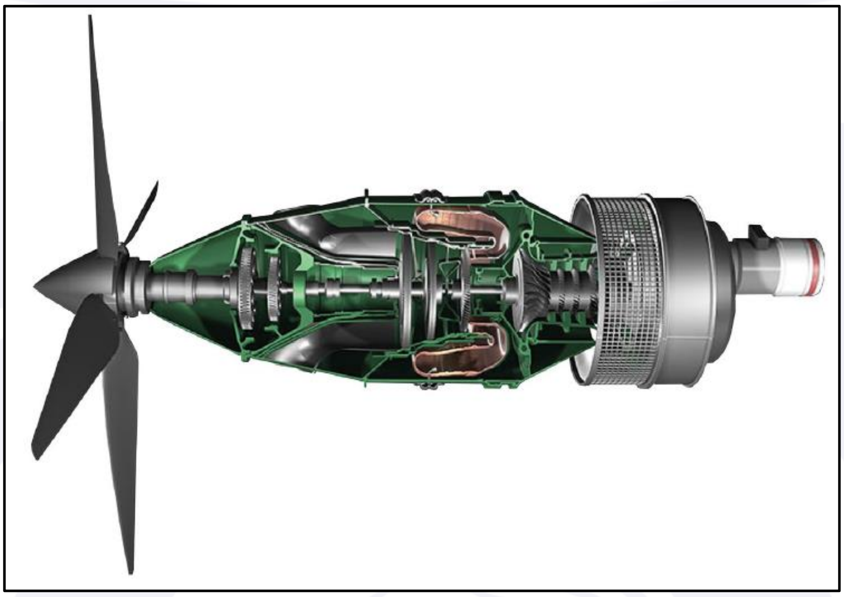


Figure 5 - Cutaway view of the PT6A-52 engine equipping the PS-CSM aircraft.
Source: aircraft training material - TRU Simulation Training.

Both turbines were located at the approximate center of the engine, with their shafts extending in opposite directions. The system was reverse-flow, with the air supply entering the lower part of the nacelle and passing through the rear protective screens. After being compressed, the air was directed to the annular combustion chamber, where it mixed with fuel sprayed by 14 nozzles mounted around the gas generator housing.

Ignition was performed by a capacitive discharge unit and two igniter plugs. Fuel control was pneumatic and maintained the regime set by the gas generator power lever. The propeller speed remained constant in any position of the power lever, except in the beta range, where the maximum speed was controlled by the pneumatic section of the propeller governor.

The accessory box, located at the rear of the engine, drove the fuel pumps, fuel controller, oil pumps, starter/generator, and tachometer generator. At this point, the drive unit speed (N1) was equal to the engine compressor speed, which was 37,468 RPM (corresponding to 100% N1). The maximum continuous speed was 39,000 RPM, equivalent to 104% N1.

The reduction box, forward of the power turbine, drove the propeller, propeller tachometer generator, propeller overspeed governor, and propeller governor.

The speed of engine power turbine at 100% N1 was 30,145 RPM, and after gear reduction, the propeller speed was 2,000 RPM, corresponding to 100% N2.

Propeller System

Each engine was equipped with a four-bladed composite, featherable, constant-speed propeller with centrifugal counterweights, reversible and with variable pitch, mounted on the output shaft of the engine reduction gearbox.

Propeller pitch and speed were controlled by engine oil pressure through engine-driven single-acting propeller governors. Centrifugal counterweights, assisted by a feathering spring, moved the blades to the feathered position. Engine oil pressure boosted by the governor moved the propeller to the high RPM (minimum pitch) and reverse positions.

The minimum propeller pitch position was determined by the Low Pitch Stop, which was a mechanically actuated hydraulic limit. This mechanism allowed the blades to rotate beyond the minimum pitch position and into the reverse position when selected during ground operations.

The blade angles in beta and reverse were controlled by means of the power levers in the beta and reverse ranges, moving the governor beta valves.

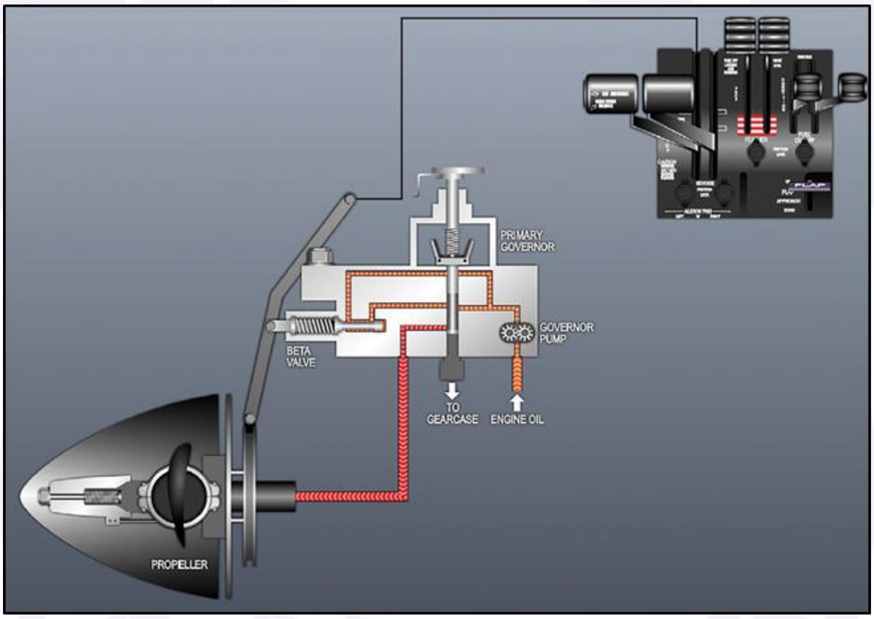


Figure 6 - Propeller system, governor, and control levers.
Source: aircraft training material - TRU Simulation Training.

a) Constant Speed Units (CSU - propeller governors).

Two governors (namely, a constant speed governor and an overspeed governor) controlled the propeller. The constant speed governor, mounted on top of the reduction gear, had the function of controlling the propeller throughout its operating range.

The propeller control lever would operate by means of this governor. Should the constant speed governor fail and allow more than 2,000 RPM, the overspeed governor would intervene at 2,120 RPM and drain the propeller oil to maintain the RPM at approximately 2,120 RPM.

As for the operating characteristics of the system, one verified that:

- a solenoid actuated by the PROP GOV - TEST switch, located on the pilot's left sub-panel, was provided to reset the overspeed governor to approximately 1,830 to 1,910 RPM for testing purposes;
- should the propeller lock up or move too slowly during a transient condition, causing the propeller governor to delay in acting to prevent an overspeed condition, the

power turbine governor, contained within the constant speed governor housing, would act as a fuel topping governor;

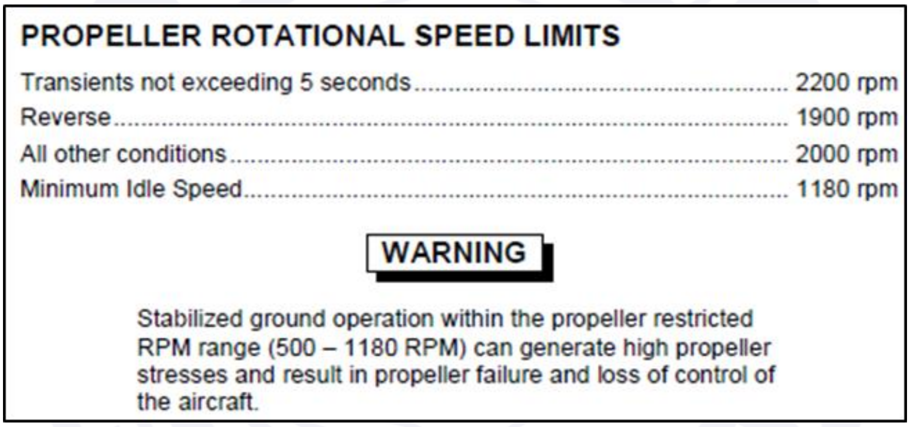
- should the propeller reach 2,120 RPM, the fuel topping governor would limit fuel flow to the gas generator, reducing the N1 RPM, which in turn would prevent the propeller RPM from exceeding 2,200 RPM, approximately; and
- during reverse range operation, the fuel topping governor would be reset to approximately 95% of the propeller RPM before the propeller reached a negative pitch angle. This ensured that engine power was limited to maintain a propeller RPM slightly lower than the constant speed governor setting.

Thus, it was possible to observe that the system was designed in such a way that the constant speed governor would be able to detect a low speed condition and direct oil pressure to the propeller piston in order to allow operation in the beta and reverse ranges.

b) Operating parameters of the Overspeed Governors.

The maximum propeller overspeed limit was 2,200 RPM, limited to five seconds. In this system, sustained propeller overspeed above 2,000 RPM would indicate failure of the primary governor.

Based on the operating manual, one observed that the flight could continue with propeller overspeed up to 2,120 RPM, as long as the torque was limited to 1,800 lb. ft. Sustained propeller overspeed above 2,120 RPM would indicate failure of both the primary and secondary governors, and such a condition was not approved by the manufacturer.



PROPELLER ROTATIONAL SPEED LIMITS

Transients not exceeding 5 seconds	2200 rpm
Reverse	1900 rpm
All other conditions	2000 rpm
Minimum Idle Speed	1180 rpm

WARNING

Stabilized ground operation within the propeller restricted RPM range (500 – 1180 RPM) can generate high propeller stresses and result in propeller failure and loss of control of the aircraft.

Figure 7 - Propeller RPM limits.

c) Autofeather System

The aircraft's automatic feathering system provided a means to immediately discharge oil from the propeller servomotor, allowing the pitch spring and counterweights to quickly drive the propeller to the feathered position in the event of an engine failure.

The system was enabled by means of a switch on the pilot's left panel, marked AUTOFEATHER - ARM - OFF - TEST.

When the switch was set to the ARM position, and both power levers were above approximately 90% N1, an 'AFX' warning was displayed next to the corresponding propeller indication both in the EICAS (Engine Indication and Crew Alert System) window and in the engine synoptic window, indicating that the system was armed. If either power lever was not above approximately 90% N1, the system was disarmed, and the 'AFX' warning was not displayed.

With the landing gear extended and the automatic feathering switch turned off, the message AUTOFEATHER OFF would be displayed on the EICAS.

The system could be tested on the ground by using the TEST option of the switch, which was a temporary position. With the switch in the TEST position, the 90% N1 sensors were disabled, and the system was armed with the power levers set to approximately 500 lb. ft. of torque.

Regarding the operation of this system, an engine failure would be simulated upon reducing a single power lever, and the resulting action of the automatic feathering system could be verified. In this test, since the engine was not actually shut down, the 'AFX' warning on the EICAS and synoptic window of the engine being tested was activated and deactivated as the torque oscillated above and below 260 lb. ft.

d) Propeller Synchrophaser.

The propeller synchronizer system, certified for all takeoff and landing operations, automatically adjusted the propeller RPMs to keep them in phase, reducing cabin noise.

Before it was activated, the RPM of each engine had to be manually adjusted so that they were within a maximum difference of 10 RPM between them.

Once the system was activated, synchronization was maintained by adjusting the RPMs as necessary to maintain engine performance. The system operated in such a way so as to never reduce the RPM below the value set by the control of the propeller with the higher RPM.

To change the RPMs with the system activated, both controls needed to be adjusted equally. If the synchronizer could not maintain synchronization, the pilot was required to deactivate the system, manually readjusting the RPM, and then reactivating it.

<u>Throttle Pedestal</u>

- Power Levers:

The power levers provided control of the engine power from idle to takeoff power by operating the gas generator (N1) governor in the fuel control unit. An increase in N1 speed would result in an increase in engine power.

- Propeller Levers:

Each propeller lever operated a speeder spring within the CSU to reposition the pilot valve, resulting in an increase or decrease in propeller RPM. For feathering, each propeller lever raised the pilot valve to a position that caused the complete discharge of high-pressure oil, allowing the counterweights and feathering spring to adjust the blade angle.

Stops at the end of the lever travel prevented inadvertent movement into the feathering range. The operating range was from 1,600 to 2,000 RPM

- Condition Levers:

The condition levers had three positions: FUEL CUTOFF, LOW IDLE, and HIGH IDLE. Each lever controlled the fuel cutoff function of the fuel control unit and set the idle speed to approximately 61% N1, or as required to maintain 1,180 RPM for the propeller in low idle, and 70% N1 for high idle.

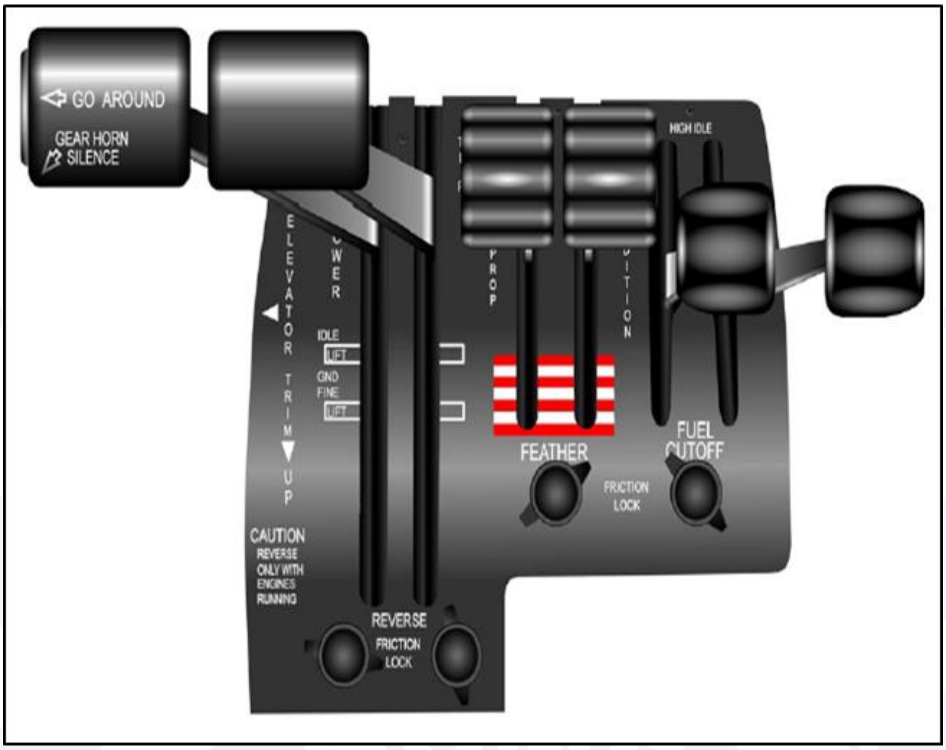


Figure 8 - Thrust pedestal.
Source: Aircraft training material - TRU Simulation Training.

<u>Engine Indication and Crew Alerting System (EICAS)</u>

The EICAS was a dedicated display that integrated engine instruments, temperature information, and messages from the Crew Alert System (CAS).

The EICAS display was divided into four areas, indicating parameters such as torque, Inter Turbine Temperature (ITT), and propeller rotation speed (measured in RPM).

The engine parameters displayed were color-coded to correspond to their respective ranges and limits.

As long as the parameters were within the normal range, the indications appeared in green. When they reached or exceeded the limits, the display changed to amber or red, depending on the value exceeded.

The CAS provided the crew with plain text messages for WARNING (red), CAUTION (amber), ADVISORY (cyan), and STATUS (white), in that order of priority.

Abnormal and emergency procedures in this section were linked, when applicable, to the messages mentioned below.

- Aural Alerts - Audible Warning Signals

PRIORITY	AURAL ALERT	DESCRIPTION	DURATION
1	Overspeed	Repetitive swept frequency tone; increasing from 500 Hz to 1,670 Hz about 5 times per sec.	Continuous
2	Stall Warning	1 kHz Continuous Tone	Continuous
3	Master Warning	Triple Chime	Single
4	Left Engine	Voice warning "LEFT ENGINE", 800 ms delay, "LEFT ENGINE"	Single
5	Right Engine	Voice warning "RIGHT ENGINE", 800 ms delay, "RIGHT ENGINE"	Single
6	Autopilot Disconnect	Warble tone, 460 Hz average, modulating continuously , 5 times per second	Repeats
7	Cabin Altitude Warning	Voice warning "Cabin Altitude", 900 ms delay, repeat	Repeats
8	Landing Gear	500 + 50 Hz, on 0.375 + 0.1 second, off 0.375 + 0.1 second, continuous	Repeats
9	Altitude Alert	Steady musical "C" chord tone	Continuous
10	Caution attention	Single Chime	Single

Table 1- PS-CSM Aural Alerts.

- Stall Warning System

The stall warning system consisted of a transducer, a lift computer, a warning horn, and a test switch.

The angle of attack was detected by the aerodynamic pressure on the lift transducer located on the leading edge of the left wing. When a stall was imminent, an output signal from the sensor activated a stall warning tone (Figure 9).

Figure 9 - Stall warning system sensor transducer.
Source: aircraft training material - TRU Simulation Training.

The system could be tested preflight by means of a spring-loaded switch marked STALL WARNING TEST on the left subpanel of the right-hand pilot station.

Holding this switch in the STALL WARNING TEST position activated the warning horn tone and a STALL indication next to the airspeed scale on the Primary Flight Display (PFD).

1.7. Meteorological information.

SDPW did not feature weather services. The METAR of SDAM (*Campos dos Amarais - Prefeito Francisco Amaral* - State-Aerodrome, *Campinas*, State of *São Paulo*, at 30 NM from the accident site) contained the following information:

METAR SDAM 141100Z 06003KT CAVOK 12/25 Q1015=

METAR SDAM 141200Z 04006KT CAVOK 11/28 Q1016=

Based on video recordings, one verified that the weather conditions were above the minimum required for the flight, with visibility greater than 10 km, without significant clouds. The wind was approximately 050° at 5 kt. (Figure 10).

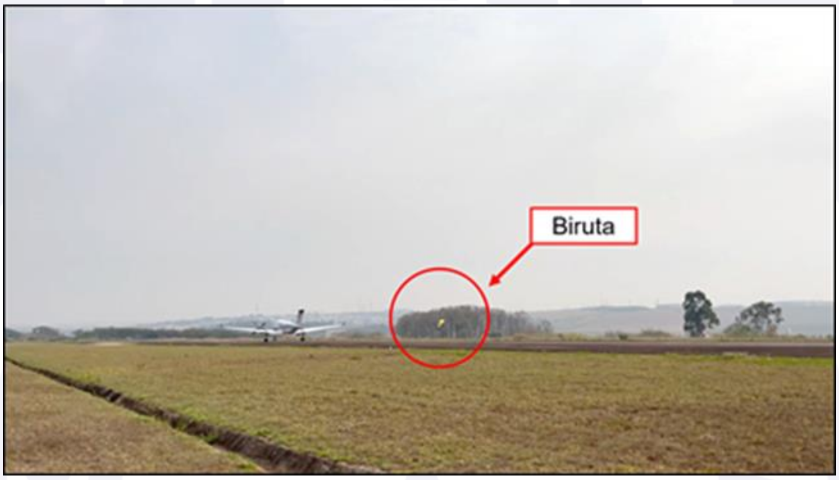


Figure 10 - Screenshot of a video recording made by an observer, with the SDPW windsock in highlight.

1.8. Aids to navigation.

NIL.

1.9. Communications.

From the CVR recorded audio, it was possible to evaluate segments of the communication between the PS-CSM aircraft and the control agencies, as well as between the said aircraft and the local coordination of SDPW, both on the day of the accident and on the day before.

In order to support the analysis of the operational aspects addressed in this report, some parts of the transmissions were highlighted. The times mentioned in this section are referenced to the CVR’s own time counter.

With regard to the flight between SBJD and SDPW on the day prior to the occurrence, at the mark of 36 minutes into the recording, the aircraft made its first call to *Jundiaí* GND control. The clearance issued to the aircraft included climb to FL260, takeoff from runway 36 with a left turn, contact *São Paulo* APP on frequency 129.5 MHz after passing JAPI gate.

After receiving approval for the engine start, the PIC requested the 2P* to check if any "switch was out." While they were analyzing aspects of the cabin, the 2P* reported that something was "loose" in the cockpit, and then asked the PIC if they should call on someone from the local maintenance organization.

At the mark of 42 minutes, the PIC confirmed the engine start-up clearance and began to proceed accordingly.

After engine start-up, the 2P* asked if he could request taxi clearance, and the PIC instructed him to run the checklist. During the before-taxi checklist, after checking the cabin lights and turning on the furnishings, the 2P* checked the cabin windows and noticed that one of them was "black," asking the PIC if that was normal. The PIC went over to the window and, after attempting to sort out the issue, asked the 2P* to shut down the engines.

At the mark of 46 minutes and 27 seconds, the 2P* called ground control and informed that they had shut down the engines due to an issue with the aircraft. Ground control replied that the flight plan remained valid and that GND control would be awaiting a new call for engine start-up.

After the services carried out by the maintenance team, related to a malfunction with one of the passenger cabin windows, at the mark of around 56 minutes into the recording, the 2P* asked if he could request engine start-up anew, mentioning that he had sent a flight plan update message (DLA) for 13:45 (local time), since the previous flight plan had a start time of 13:00 (local time). In contact with ground control, the 2P* received engine start-up approval.

At the mark of 57 minutes and 27 seconds, the PIC requested clearance, and initiated engine start-up. About two minutes later, the 2P* began reading the before-taxi checklist. At the mark of 1 hour, 1 minute, and 9 seconds, the 2P* requested taxi clearance, which was granted by *Jundiaí* ground control.

The takeoff was authorized by the tower at the mark of 1 hour, 9 minutes, and 47 seconds into the recording. The takeoff effectively took place at "four one," as informed by the tower control.

At the mark of 1 hour, 15 minutes, and 34 seconds, the PIC requested clearance from *São Paulo* APP to "proceed visually via the corridors," to which the controller authorized him to proceed as requested, maintaining "maximum corridor speeds." Following these radiotelephony exchanges, the PS-CSM coordinated with other aircraft on the corridor frequency.

At the mark of 1 hour, 26 minutes, and 48 seconds, the PIC asked the 2P* whether it was "130.55," referring to the coordination frequency for *Piracicaba* (*Pegasus*), to which the 2P* confirmed although expressing some doubt. The PIC then transmitted a message on that frequency, calling "*Pegasus*," and inquired about the conditions at SDPW.

Pegasus informed that there was no traffic, and suggested runway 35 for landing. The PIC stated that they were 5 minutes out and asked if the passengers were at the aerodrome already, and *Pegasus* replied that the "son and wife had already arrived."

At the mark of around 1 hour and 31 minutes into the recording, the 2P* reported being on the final approach for runway 35 of SDPW, and no further transmissions were made on that flight.

On the accident flight, in turn, transmissions for coordination were made at SDPW for taxiing, entry onto the runway via the central intersection, and backtrack to runway threshold 35.

At the mark of 2 hours, 3 minutes, and 39 seconds, the 2P* transmitted that they had taken off at "three five." Approximately 10 seconds later, the pilot transmitted that the aircraft would be returning to the runway. That was the last external communication recorded by the CVR.

1.10. Aerodrome information.

The aerodrome was public, under the administration of the local government, and operated VFR during day- and night-time. It featured an asphalt-sealed runway, with thresholds 17/35, measuring 1,200 m x 30 m, at an elevation of 1,917 ft.

The declared distances for Take-off Run Available (TORA), Take-off Distance Available (TODA), Accelerate-Stop Distance Available (ASDA), and Landing Distance Available (LDA) corresponded to those described in the Air Routes Auxiliary Manual (ROTAER), as shown in Figure 11.

RWY	TORA(m)	TODA(m)	ASDA(m)	LDA(m)
17	1200	1200	1200	1200
35	1200	1200	1200	1200

Figure 11 - Table with the declared distances of the SDPW runway.
Source: ROTAER, D-AMDT 47/22.

1.11. Flight recorders.

The aircraft was equipped with an L3 FA2100 Series CVR (PN 2100-1025-22, SN 2009283) manufactured by L3 Harris.

The voice recorder was sent to the LABDATA (Flight Data Recorders Readout and Analysis Laboratory) of CENIPA, which coordinated the data download with the NTSB (USA's National Transportation Safety Board).

The equipment functioned normally, and contained approximately two hours and four minutes of audio recordings, including the aircraft's ferry flight from SBJD to SDPW on the day before the occurrence, as well as the accident flight.

1.12. Wreckage and impact information.

The impact of the aircraft into the terrain was one of high-energy, mainly due to the high rate of descent performed in the final moments of the flight (Figure 12).

Figure 12 - Image of the aircraft in the moments preceding the impact, obtained from a video captured by a Closed Circuit Home Surveillance System (CCTV).

Since the aircraft had taken off with its tanks full of fuel, the impact was followed by an explosion, which set the wreckage and surrounding terrain on fire (Figure 13).

Figure 13 - Aerial image of the wreckage obtained during the Initial Action.

The degree of destruction and charring of the aircraft made it difficult to check pieces of equipment and instruments, also rendering it impossible to observe the throttle pedestal.

The left-hand engine was fractured by the impact energy, and its air intake was partially separated. The right-hand engine was also fractured at its reduction gearbox housing, separating into two parts. Both propellers had all blades fractured close to the hubs of each of these components, due to the impact.

1.13. Medical and pathological information.

1.13.1. Medical aspects.

No evidence was found that physiological or incapacitation issues might have affected the performance of the pilots.

1.13.2. Ergonomic information.

NIL.

1.13.3. Psychological aspects.

The PIC was 39 years old, and everyone described him as a professional dedicated to aviation, and who performed his activities with high motivation. As aviation was his great personal passion, he earned his first license shortly after turning 18, starting his professional career less than two years later, in 2002.

Throughout his professional history, he worked for various air taxi companies, initially as a co-pilot and, since 2005, as a captain of single and multi-engine aircraft.

Along his career, the PIC also did several courses, such as Crew Resource Management (CRM), International Air Traffic, Reduced Vertical Separation Minima (RVSM), Performance-Based Navigation (PBN), and basic ground school courses of a variety of aircraft, including the Cheyenne Series I/II, Learjet 55, Citation 525, EMBRAER 110 *Bandeirante*, and Beechcraft King Air (B200GT).

The PIC had been hired in 2019, under recommendation made by the chief pilot of the aircraft fleet that belonged to the brother of the PS-CSM owner. The said chief pilot had known him for a long time and considered him to be an excellent pilot.

He participated in the final stages of the PS-CSM delivery in the United States, the country of manufacture. Prior to the transfer of the aircraft, he underwent an initial training on a simulator, which included the aircraft's normal procedures, to familiarize the pilot with the aircraft. The investigation team did not have access to records indicating the pilot's performance during this training.

According to information collected, another simulator session would be held in November of the year of the accident, with the purpose of refining the pilot's skills and training him for contingent emergencies.

Among the employees who worked in the hangar where the aircraft remained most of the time, the PIC was considered a “quiet person” who was always very friendly, concerned with flight safety aspects and as someone who complied with the checklists.

Many of his acquaintances said that, in the months preceding the accident, the PIC looked stressed and overwhelmed with aircraft maintenance-related issues, which were monitored by him.

There were reports that he frequently complained about the aircraft's dispatchability, pointing out that it would “break down” all too frequently. In particular, the events related to the repair of the left propeller had a considerable effect on the PIC's emotional aspects. The repairs represented high costs for the owner, who questioned the OM as to whether it was pertinent for him (the owner) to assume such costs.

Regarding this issue, it was noted that the PIC experienced relationship difficulties with the Maintenance Organization responsible for the most recent interventions on the aircraft, to the point of having conflicts with one of the managers.

This happened possibly due to criticisms the PIC had made about the services provided, as well as on account of his efforts to hasten the aircraft’s release during the last inspection, something that had been requested by his employer.

According to collected reports, the PIC maintained a good relationship with his employer and was generally listened to when offering suggestions or expressing concerns related to flight safety, particularly regarding weather conditions.

In the last inspection mentioned, however, the OM initially scheduled the aircraft’s release for Wednesday, 15 September 2021. Nonetheless, the owner made several efforts to hasten the completion of the work, aiming to use the aircraft on the previous Friday, 10 September 2021.

A proposal for overtime was sent to the owner, who refused the additional costs and was satisfied with advancing the release to the morning of Monday, 13 September 2021.

Relatively to the operation of the aircraft, despite having operated in a single-pilot condition for nearly two years, the PIC was receptive to the idea of having a copilot.

The 2P*, in turn, was 24 years old and was described by everyone as extremely passionate about aviation, very dedicated, and studious. He began his aviation career in 2016, also at 18 years of age. He also supplemented his aviation training in the United States, having attended a course at Embry-Riddle Aeronautical University.

Later, he began working as a flight instructor at the same school where he completed his initial training, a role he performed with great motivation until being invited to operate the PS-CSM airplane in December 2020.

According to reports, even though the 2P* had not undergone training in the B200GT aircraft simulator, he had good understanding of the aircraft systems and mastered the operation of its avionics, proactively assisting the PIC in this regard.

The relationship between the pilots was described as 'healthy' and 'friendly.' The CVR audio recordings indicated cordiality in their interactions, showing that the PIC placed himself in a position to impart knowledge and experience to the 2P*, allowing him to operate the controls and participate in the decision-making in the cockpit.

According to reports, the pilots were eager for more frequent flights on the PS-CSM, which they believed would happen after the last maintenance intervention that had been completed.

As for the flight in question, the intention was to transport the employer and his family to one of their farms, where they would stay for a few days. As it was determined, there were several attempts to advance the flight, which is why the departure from SBJD the previous day took place under some pressure of the owner.

The pilots planned to depart for the farm on 13 September 2021, but an issue with one of the windows delayed the release of the aircraft, causing the flight to be postponed to the following day, which left the employer dissatisfied.

Due to the length of their stay on the farm, the passengers carried considerable amounts of luggage and various other items, such as food and beverages. Regarding the aircraft's weight and balance limits, reports obtained from other pilots of the same aircraft model revealed a widespread belief that the aircraft's certification was "conservative," making it possible to carry whatever was necessary. It was also noted that the employer even remarked that the “King Air was capable of taking off with just one engine.”

Upon discussing the subject of the Maximum Takeoff Weight (MTOW) with other pilots who had had contact with the PIC, one observed that there was widespread confidence that the aircraft indeed had the capacity to operate above its weight and balance limits.

Regarding the accident flight, it is worth mentioning that the propeller RPM above normal takeoff parameter was identified by the PIC and conveyed to the 2P* in a calm and composed manner, without signaling urgency or high severity.

The 2P*, as in other interactions recorded by the CVR, showed proactivity and promptly called the aerodrome coordination on the pertinent frequency to inform that the aircraft would return to the runway, as had been agreed in the briefing.

1.14. Fire.

The fire started immediately after the impact. The combustible materials were fuel and aircraft debris.

The fire department of the municipality of *Piracicaba* began their efforts to extinguish the fire just over twenty minutes after the accident, but the amount of fuel present caused the fire to continue consuming the wreckage for more than an hour after the aircraft crashed.

1.15. Survival aspects.

There were no survivors among the occupants of the aircraft.

1.16. Tests and research.

In order to identify the factors that contributed to the events related to the aircraft's turboprop powerplant, both engines were removed from the rest of the wreckage, together with the CSU and Overspeed Governors (OSG), for further analysis.

During the engine analysis, the left and right propeller hubs were detached in order to be analyzed individually.

It was also determined that the CSU and OSG required a more in-depth examination with the support from the manufacturer of these components.

In addition to these examinations, the CENIPA’s LABDATA and the NTSB conducted analyses of the sound spectrum recorded by the aircraft's CVR during the accident flight, so that the data obtained could complement the analyses of the components.

<u>Analysis of the Turboprop Powerplant</u>

The PT6A-52 left- and right-hand engines (respectively, SN RX0972 and SN RX0947) that equipped the PS-CSM aircraft were analyzed at the Pratt & Whitney facilities located in the city of *Sorocaba*, State of *São Paulo*.

Figure 14 - Left-hand engine (SN RX0972) damaged by impact and fire, showing fracture and partial separation of the air intake.

Figure 15 - Right-hand engine (SN RX0947) damaged by impact and fire, separated into two parts at the reduction gearbox.

The analyses were carried out with the support of engineers from Pratt & Whitney Canada and Pratt & Whitney Sorocaba, as well as members of the Investigation Committee.

The results of the analyses converged on the conclusion that both the left- and right-hand engines showed contact signatures on their internal components, indicating that both engines were functioning at the moment of impact.

One verified that the engines did not exhibit any evidence of anomalies or prior issues in the analyzed components that could have prevented their normal operation before the impact.

<u>Analysis of the Propellers and Blades</u>

The left- and right-hand propellers equipping the PS-CSM aircraft were of the HC-E4N-3A model with NC9208K propeller blades and had serial numbers NR511 and NR505, respectively.

The hubs of these components and a fractured, unnumbered propeller blade were analyzed at the Hartzell Propeller Engineering Test Lab, located in Piqua, Ohio, USA (Figure 16).

Figure 16 - NR511 (left) and NR505 (right) propeller hubs
shown at the beginning of the analyses.

The analyses were conducted by a specialized investigator from the manufacturer, and were observed by a representative of Textron Aviation (manufacturer of the aircraft), by the NTSB’s accredited representative, and by members of the SIPAER Investigation Committee.

In order to facilitate understanding of the terms used in this subsection, Figure 17 shows a cross-section of the HC-E4N-3A propeller model, which was installed on the PS-CSM aircraft.

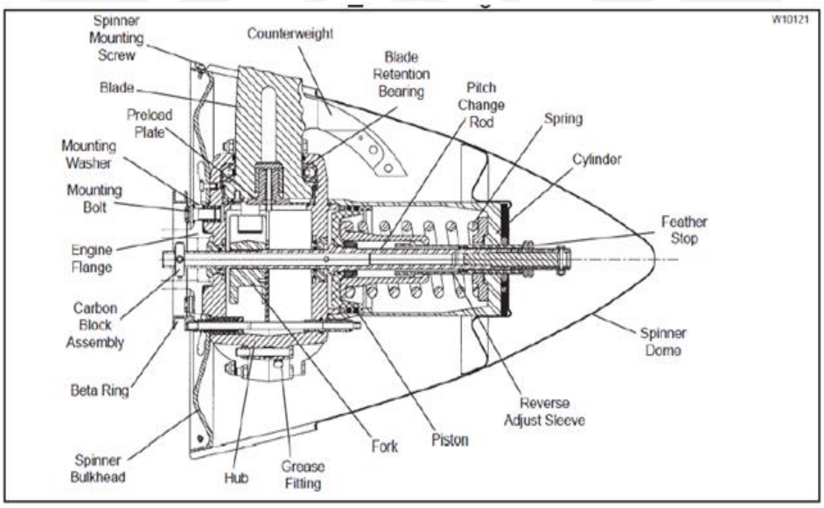


Figure 17 - Cross-section of the HC-E4N-3A propeller model.

The propellers were disassembled for access, visualization, and removal of the internal components.

The measurements of the impact marks on the preload plates and forks were noted down and analyzed to estimate the blade angles of each propeller, as well as the power state of each engine at the moment of impact.

The blade fragment was examined to help determine the impact angles of this material.

Both propellers exhibited damage on the dowel pin holes at the base of their respective hubs, indicating that there was torque (or power) in the engines at the time of impact.

The impact signatures on the notches of the left propeller's forks indicated that it was operating at a higher RPM compared to the right propeller.

The notches on the right propeller's forks had impact marks on the blade's eccentric pins (knobs), suggesting that the blades were operating in the 60° to 78° range at the moment of impact, which would be consistent with a feathering process (Figure 18).

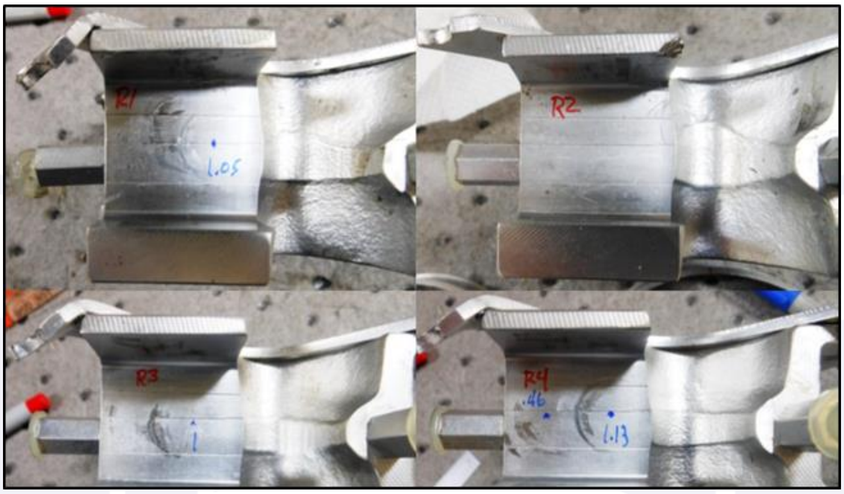


Figure 18 - Impact marks on the notches of the right-hand propeller forks.

It is worth noting that, at the time of the analysis, the pitch change system of the right propeller was in the minimum pitch position.

This condition indicates the possibility that the impact forces moved the system into this position, or that the pilot attempted to undo the feathering shortly before impact, initiating the movement of the blade angle towards the minimum pitch.

All damage observed on the propellers was consistent with high impact forces and exposure to fire.

<u>Analysis of the Constant Speed Units (CSU)</u>

The left and right CSUs (respectively, SN 21424227 and SN 21285544) were analyzed at the facilities of Woodward Inc., located in the city of Loves Park, Illinois, USA.

The analyses were conducted by engineers and technicians of the manufacturer, observed by the NTSB’s Accredited Representative and by members of the SIPAER Investigation Committee.

The items were initially subjected to a visual inspection for verification of their general condition and as a preliminary assessment of their mechanical conditions.

All components showed evidence of impact damage and signs characteristic of exposure to high temperatures, consistent with ground impact followed by explosion and fire.

During the inspection of the SN 21424227 and SN 21285544 CSUs, it was found that the lockwires of the eccentric bolt, the maximum and minimum RPM stops, the speed lever, and the control lever stop were not of the Woodward manufacturer's standard (non-Woodward lockwires).

Figure 19 -SN 21424227 and SN 21285544 propeller governors (CSU), during visual inspection.

This condition indicated that adjustments had been made to the components, which could have occurred either during their integration with other aircraft components or during their operational cycle. It should be noted that there were no maintenance records related to these adjustments, nor was there any requirement for them.

It was found that torque sealant was missing on the eccentric bolt, on the reset lever stop bolt, and on the maximum speed control lever of each CSU. However, it is important to highlight that these sealants would not necessarily have been resistant to the high temperatures to which the components were subjected after the impact.

During this analysis, the CSU units underwent radiographic inspection to evaluate the internal conditions of the reset lever, as they exhibited restricted movement, almost jammed, and would be activated during the tests. The radiographic inspection found no signs of bending, debris, or foreign objects, nor were there any anomalies detected in the assembly.

After the visual and radiographic inspections, the governors were bench-tested. However, due to the fact that they had been subjected to impact and fire, normal functional values and tolerances were not expected. Upon completion of the tests, the CSU units were disassembled for analysis of their internal parts.

It was evidenced, through the inspections carried out during the disassembly of each CSU, that the test values obtained (outside their respective tolerances) were related to the damage caused by the impact with the ground, the damage caused by the heat from the post-impact fire, or by subsequent movements.

The records of the tests (ATP data sheets) conducted by the manufacturer at the time of delivery of the CSU and OSG to the aircraft manufacturer were also verified, confirming that all parameters were within the specified limits.

Finally, the analysis of these units indicated that there was no evidence of a pre-existing condition that could have prevented their normal operation.

<u>Analysis of the Overspeed Governors (OSG)</u>

The left and right OSGs (respectively, SN 21873538 and SN 21873533) were analyzed under the same circumstances as the CSUs.

The OSGs underwent visual inspection and showed signs of charring, consistent with exposure to intense fire after the impact with the ground (Figure 20).

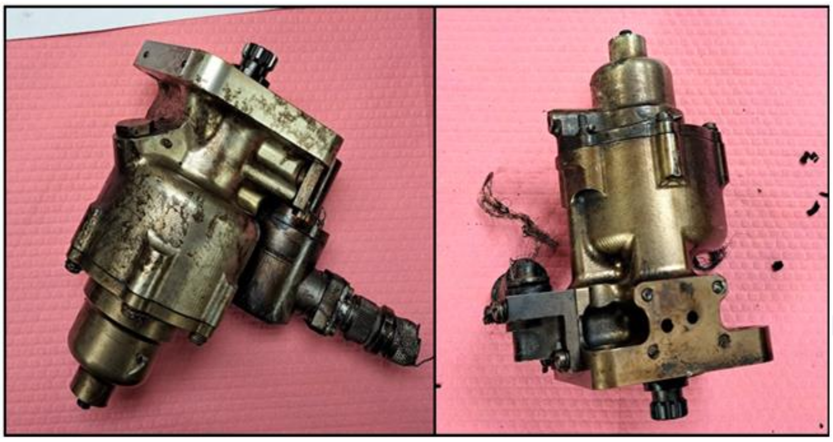


Figure 20 - SN 21873538 and SN 21873533 overspeed governors.

Both units lacked the tamper-proof sealant on the maximum speed adjustment screw, indicating that the original sealant might have been removed after leaving the factory.

These tamper-proof sealants are also known in aviation as "faith lines," literally a line of highlighted paint, usually yellow, painted from the body of the overspeed governor to the top of the maximum speed adjustment screw.

However, given the conditions to which these units were exposed, it is possible that these sealants or faith lines may have been consumed by the fire.

Despite the state at which these components were found, bench tests were conducted on both units in order to search for evidence of malfunction that could have contributed to the occurrence.

In both tests, the values obtained outside their respective tolerances were attributed to damage caused by the impact with the ground, by the heat from the post-impact fire, or subsequent movements.

For both overspeed governors (SN 21873538 and SN 21873533), the tests indicated that there was no evidence of pre-existing conditions that could have prevented their normal operation.

Analysis of the CVR Sound Spectrum

After retrieval of the audios recorded by the CVR, the audio signal was processed for identification of the characteristic frequencies associated with propeller rotations.

Based on these frequencies, the propeller rotation speeds were calculated and documented by CENIPA's LABDATA, as well as by the NTSB.

The differences found between the analyses, although not having significant effect on the conclusions of this report, are due to the characteristics of the software used in processing the audio.

The products generated by the CENIPA and by the NTSB were also analyzed in conjunction with the manufacturer of the propellers, leading to the following findings:

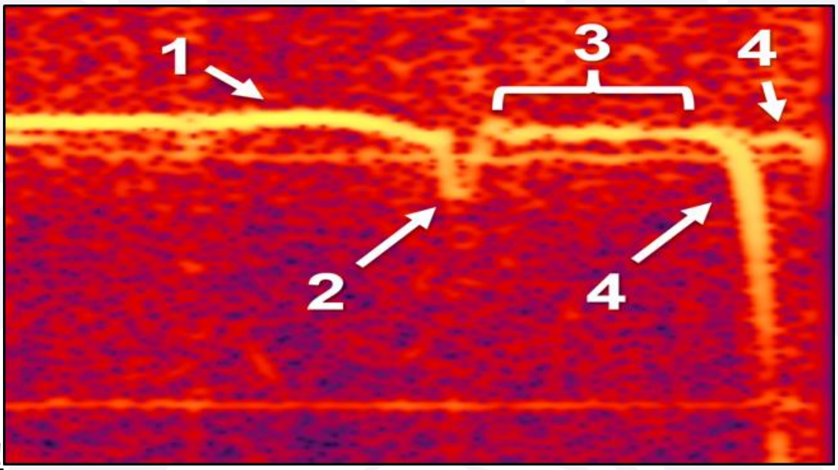
In the analysis conducted by the LABDATA, the following information was obtained, listed from "1" to "4," corresponding to the illustration of Figure 21:

1. Approximately 16 seconds before impact, there was an increase in propeller rotation to 2,025 RPM (101.25% N2);

2. About 12 seconds before impact, the propeller rotation decreased to 1,830 RPM (91.5% N2), which represents a 9.75% drop within a 4-second interval;

3. Approximately 10 seconds before impact, the propeller speed returned to 2,000 RPM (100% N2) for 6 seconds; and

4. About 4 seconds before impact, the speed of one of the propellers oscillated slightly, while the other one dropped abruptly.



!

Figure 21 - Pictographic representation of the sound spectrum obtained from the CVR audio recordings.

In the analysis conducted by the NTSB, point 1) was identified as the maximum propeller rotation value reached, for which a speed of 2,008.5 RPM was obtained.

The “propeller overspeed” call-out was made by the PIC about two seconds later, when the speed calculated from the spectrum was 1,995 RPM.

The lowest speed obtained 2) was also calculated to be 1,830 RPM. The segment identified in 3) was calculated to be 1,968 RPM.

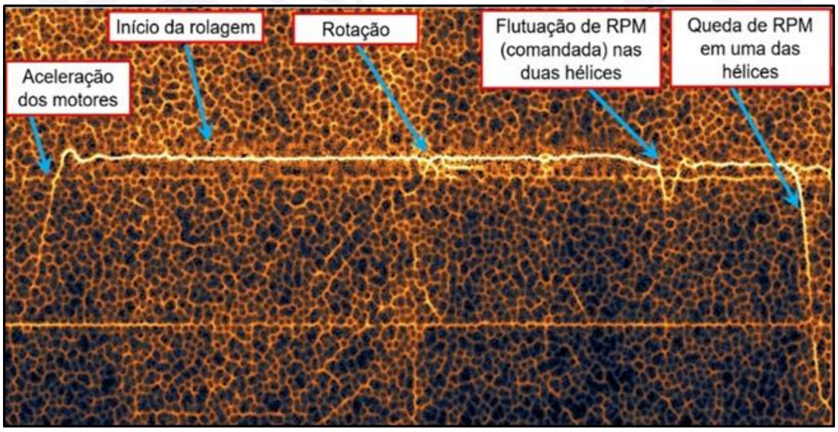


Figure 22 - Pictographic representation of the acoustic spectrum of the entire accident flight, obtained by the NTSB.

In accordance with the report produced by the propeller manufacturer, the noise signal that rapidly dropped just before impact is consistent with the feathering of one of the propellers.

The time for the drop from approximately 2,000 RPM (133 Hz) to approximately 1,005 RPM (67 Hz) at the end of the recording was less than 4-5 seconds.

The high rate of reduction and the RPM reached are consistent with a feathering event.

Additionally, the report showed that previous flight tests of a 4-blade propeller on this aircraft model indicated that the flight idle RPM, at a speed of approximately 104 kt, was around 1,750 RPM, and close to the stall speed (about 90 kt. calibrated airspeed), it was around 1,600 RPM.

The drop in the noise trace in the accident spectrum began to stabilize at around 1,065 RPM, and the recording ended with the RPM close to 1,005. Therefore, it was noted that these parameters were below the expected idle RPM for a propeller at the minimum pitch stop.

The report also highlighted that the noise signal presented sound pressure levels relatively high, suggesting that the feathering occurred from a moderate to high power setting, not from a low or idle power.

1.17. Organizational and management information.

Aircraft Operator's Structure and Management

The aircraft was operated by a private company, owner of the PS-CSM and of a Piper PA-46, which were used for transport between the owner’s farms. Their operation was conducted in accordance with the provisions of the RBAC 91 - "General Operating Requirements for Civil Aircraft."

The PS-CSM shared a hangar with other aircraft belonging to the *Raízen Energia S.A.* company in the city of *Piracicaba*, State of *São Paulo*.

The hangar employees, who provided services to the referred company, routinely received the PS-CSM aircraft, performing maintenance and cleaning activities, in addition to refueling services, luggage loading, and other arrangements.

Although there was an accounting firm responsible for most of the management tasks related to the aircraft, the PIC was responsible for overseeing these activities and advising his employer on all relevant operational aspects, as well as on the monitoring of maintenance.

Nonetheless, one observed that there was a consulting firm specializing in aircraft maintenance, responsible for the fleet of aircraft related to the brother of the PS-CSM owner, which occasionally provided advice and assistance on maintenance matters, particularly due to having unrestricted access to the maintenance organization where inspections were normally carried out.

Minimum Requirements for Operating a Specific Model of Class Aircraft

Regarding the PIC's qualifications, one verified that he met all the requirements set forth by the RBAC-61, the IS 61-004G, and the IS 61-006A, particularly in relation to the transition rules from the requirements that entailed a BE20 type-rating to those that mandated an MLTE class-rating.

However, one noted that during the period in which the Beechcraft 200 Series aircraft were classified as "type," the ratings had a validity of twelve months, according to the RBAC-61, amendment nº 06:

> 61.19 Pilot Rating Validity
>
> (a) The validity of the ratings endorsed on pilot licenses or certificates must comply with the following periods, starting from the month of the pilot’s proficiency test approval, except as provided in paragraph 61.33 (a) of this Regulation:

(1) class rating: 24 (twenty-four) months, except for ratings related to light-sport aircraft, which will have a validity of 36 (thirty-six) months;

(2) type rating: 12 (twelve) months; (emphasis added)

[...]

Thus, the flights for rating revalidation should take place annually on that same aircraft model, in accordance with the following training requirements: (emphasis added)

61.215 Type Rating Revalidation

(a) To revalidate a type rating, the applicant must:

(1) have successfully completed, within the 6 (six) months prior to the proficiency test, ground and flight training for the revalidation of the type rating for the required aircraft; and

(2) pass a proficiency test conducted in accordance with paragraph 61.213(a)(4) of this Regulation;

(b) The ground and flight training for revalidation must be conducted at a CTAC.

(c) If, by the time the candidate begins their revalidation training, there is no CTAC certified or validated by the ANAC to provide such training, the training may be provided by a PC or PLA rated and qualified on the aircraft. In this case, the training must include at least 20% (twenty percent) of the flight hours required in paragraphs 61.213(a)(3)(iii)(A), 61.213(a)(3)(iii)(B), or 61.213(a)(3)(iii)(C), as applicable.

[...]

Relatively to the provisions of paragraphs 61.215(a)(1), 61.215(b), and 61.215(c), previously mentioned, concerning the training for type rating revalidation, the following is highlighted:

61.213 Type rating grant

(a) The candidate for a type rating must meet the following requirements:

[...]

(3) flight training:

((iii) if, by the time the candidate begins flight training, there is no CTAC certified or validated by ANAC to provide the training, flight training may be provided by a PC or PLA rated and qualified on the aircraft, who must endorse this training in the candidate's logbook, provided it includes at least:

(A) 20 (twenty) flight hours for jet airplanes and 12 (twelve) flight hours for turboprop or conventional airplanes;

[...]

Regarding the provisions of paragraphs 61.215(a)(2), also previously mentioned, with respect to the required proficiency for the revalidation of the type rating, the following is highlighted:

61.213 Type rating grant

(a) The candidate for a type rating must meet the following requirements:

[...]

(4) proficiency:

[...]

(i) The candidate must pass a proficiency test conducted in an aircraft or a flight simulation training device (FSTD) qualified or validated by the ANAC. (emphasis added)

After the transition provided for by the IS 61-006, the PIC began conducting his MLTE rating revalidation flights in a twin-engine aircraft with conventional engines, having performed re-check flights on 10 July 2017, 15 June 2018, 10July 2019, with his last revalidation flight taking place on 31 October 2020, conducted in a PA-34 model aircraft, which was a twin-engine reciprocating powered airplane, in compliance with items 61.19 and 61.197 of the same RBAC 61:

> 61.197 Class rating revalidation
>
> (a) To revalidate the class rating, the holder must pass a proficiency test in an aircraft of the pertinent class.
>
> [...]

According to the PIC's CIV records, the last flight in a B200 aircraft prior to operating the PS-CSM aircraft had the purpose of re-adaptation to the model and took place in September 2015. Between September 2013 and April 2015, only flights in aircraft classified as "type," with jet engines, of the C525 and C510 models, were listed.

Thus, after the revalidation of the BE20 type rating in 2015, no flights by the PIC in B200 model aircraft were logged until October 2019, when he began operating the PS-CSM, which was already classified as MLTE Class according to the new instructions contained in the IS 61-004G.

Therefore, one observed that, since September 2015, the PIC had not performed emergency procedures in B200 aircraft, either in training or proficiency check flights for his rating revalidation.

Although he had undergone a Super King Air B250 simulator training session at Flight Safety International in 2019, the Investigation Committee found that the flight focused on training on the differences between the B250 and B200 models, and that it did not include simulated emergency training.

Since the PS-CSM aircraft was certified for Single Pilot operations, which could be conducted with a minimum crew of just one pilot, the PIC operated the aircraft as the sole crew member until December 2020, when the 2P* began occupying the right seat, despite not holding the required rating.

1.18. Operational information.

<u>Information about the Flight Conducted on 13 September 2021</u>

To provide appropriate context for the operational information related to the accident, aspects of the flight performed on the previous day were addressed, which took place after release of the aircraft by the Maintenance Organization (MO) that conducted the inspections described in item 1.6 of this report.

According to the CVR audio transcripts, the flight was planned to take place between SBJD and SDPW at FL260.

Based on the cockpit communications, it was possible to infer that the intention to climb to FL260 was due to the need to check the aircraft's pressurization system, as it had just undergone a comprehensive inspection.

These communications also revealed that there was an intention to land at SDPW to board the passengers, and continue that same day to the destination determined by the aircraft owner. To this end, the 2P* remained in contact with the refueling service at SDPW, so that they would be assisted upon arriving at the aerodrome.

The initially planned ETD (16:00 UTC) was delayed during the checks following engine start-up when the pilots noticed that one of the passenger cabin windows had a malfunction. The problem was solved by the MO, and the engines were restarted, resulting in the actual takeoff time of 16:41 UTC.

According to reports obtained by the Investigation Committee, this delay led to the rescheduling of the passenger transport flight to the following day.

All procedures of the "before-taxi checklist" were called out by the 2P* and verified by the PIC, except for the flap check, which was performed during the taxi of the aircraft.

During the "before takeoff" (run-up) procedures, when the 2P* called out the autopilot check, the PIC answered "okay," indicating that he intended to skip the system verification. When questioned by the 2P* about this, the PIC conducted the check but commented that this procedure didn't work correctly, not even in the simulator. On that occasion, all system items were checked, including the Yaw Damper and the Electric Pitch Trim.

The 2P* then said that all three trim tabs were set to "zero" and assessed the friction of the engine control levers, asking the PIC for confirmation.

When the check for governors, overspeed governors, and rudder boost was called out by the 2P*, the PIC answered "*okay*," without performing the pertinent verifications (Fig. 23).

* 8. Primary Governors, Overspeed Governors and Rudder Boost . . . .CHECK

a. Rudder Boost . . . . ON

b. Prop Governor Test Switch . . . . HOLD TO TEST

c. Power Levers (individually) . . . . INCREASE UNTIL PROP IS STABILIZED AT 1800 TO 1910 RPM

d. Prop Lever . . . . RETARD TO DETENT, THEN FULL FORWARD (to check primary governor)

e. Power Lever . . . . CONTINUE TO INCREASE UNTIL RUDDER MOVEMENT IS NOTED (Observe ITT and Torque Limits)

f. Power Lever . . . . IDLE

g. Repeat Steps c thru f on opposite engine.

h. Prop Governor Test Switch . . . . .RELEASE

Figure 23 - Checklist of primary governors, overspeed governors, and rudder boost, extracted from the Aircraft Flight Manual (AFM).

The 2P* continued the checklist, enunciating "*autofeather*", to check the automatic feathering, to which the PIC replied that he would perform this check at the runway threshold (Figure 24).

* 9. Autofeather . . . . .CHECK

a. Power Levers . . . . APPROXIMATELY 500 FT-LBS TORQUE

b. Autofeather Switch . . . . HOLD TO TEST
[L AFX] & [R AFX] - ILLUMINATED
(or, [L AUTOFEATHER] & [R AUTOFEATHER] - illuminated)

c. Power Levers . . . . RETARD INDIVIDUALLY THEN ADVANCE BACK TO 500 FT-LBS

1) At Approximately 410 ft-lbs . . . . OPPOSITE ANNUNCIATOR EXTINGUISHED

2) At Approximately 260 ft-lbs . . . . BOTH ANNUNCIATORS EXTINGUISHED (Prop Starts to Feather)

NOTE

Autofeather annunciator will cycle on and off with each fluctuation of torque as the propeller feathers.

d. Power Levers . . . . IDLE
[L AFX] & [R AFX] - EXTINGUISHED
(or, [L AUTOFEATHER] & [R AUTOFEATHER] - extinguished)
(Neither Prop Feathers)

e. Autofeather Switch . . . . RELEASE

Figure 24 - Checklist of the automatic feathering system, extracted from the AFM.

Along the next minute, still during taxi, the interactions in the cockpit suggested that the PIC had performed the autofeather checks simultaneously with the governor checks.

The PIC quickly explained the procedures to the 2P*, who seemed surprised by the simultaneous completion of both checks while the aircraft was in motion.

The rapid execution of the checks did not allow the 2P* to distinguish which items from the checklist had been completed, and when he questioned the PIC about it, he heard the answer, “*autofeather and autoignition, you can skip it*.” The 2P* inquired whether it was necessary to “press the test,” possibly referring to the prop governor test switch, and the PIC said that he had already pressed it.

The 2P* did not fully understand the checks, and later, while en route, requested the PIC to explain what had been done.

The next item of the checklist would be “*11. Manual Prop Feathering*,” but the 2P* enunciated the subsequent item (*pack and pneumatics*), and asked if the PIC wanted him to turn off the bleeds to check them properly, with the PIC replying that it was not necessary.

From the recordings, it was possible to observe that the check of the manual feathering of the propellers was not performed.

After going through the last items of that section of the checklist, the 2P* mentioned that the taxi in that location was long and, therefore, “*there’s plenty of time to get things done*”.

As the 2P* selected “3,500” (possibly referring to the rate of climb in ft. /min.), the PIC asked to check whether “*the deice will cycle twice*,” indicating another checklist item that had not been verified earlier. When they were cleared to enter runway 36, the 2P* asked if he should request a transponder code from the control tower, which the PIC dismissed, deciding at that moment that the takeoff would be performed by the 2P*, a decision that took him by surprise.

The last items of the before-takeoff checklist enunciated by the 2P* were the trim and flaps, with six items still left to be checked, when the PIC informed him that they had already received clearance, and that the throttles could be advanced.

It was observed on that occasion that no briefing for takeoff or potential emergencies was held.

During takeoff, it was noted that the 2P* announced "*speed alive*" while performing the takeoff, criticizing his own performance, and the PIC said, "*don’t worry, stick with me",* indicating that he was monitoring the 2P*'s control inputs, though the division of tasks between the pilots was unclear.

After beginning the climb, the PIC noted that the aircraft's pressurization system was functioning, and stated that it would not be necessary to climb further. The 2P* asked whether it might be better to "quickly climb to ten thousand," to which the PIC replied that it wouldn’t make a difference and that it would only delay the flight, denoting his concern about the next phase of the operation.

Subsequently, the pilots made coordination to continue the flight "via corridors" and deconflict their flight from other aircraft. En route, the PIC attempted to explain the check he had performed on the ground, mentioning that it was a "mechanic's trick."

Upon informing that he was about five minutes out of SDPW, the PIC called Pegasus (local coordination frequency) and requested to have the fueling services ready. The 2P* initiated the descent and asked if the PIC would take over the flight from that point, justifying that his performance was unsatisfactory due to the time he had spent away from flying and that, for landing, the passengers would already be at the location.

At this point, the pilots spent some time to locate SDPW aerodrome, searching for visual references on the ground.

The “*terrain*” and “*pull-up*” alarms were heard twice, indicating that the descent had exceeded the parameters of the Terrain Awareness Warning System Plus (TAWS+).

Before sighting the runway, possibly based on the distance, the 2P* asked whether he could start lowering the flaps, which was confirmed by the PIC. The same procedure was followed for the landing gear. After the flaps and gear were lowered, both pilots continued searching for the runway. The 2P* confirmed gear down and locked, and was able to locate the aerodrome approximately 3 NM away, passing the information to the PIC.

The 2P* asked if he could lower “*full flaps*”, and the PIC asked if the gear was *down*, which was confirmed by the 2P*.

In view of this, the PIC requested “*full flaps and propeller*”, and the 2P* called to inform that they were on final, while working some of the items of the “before-landing checklist”, repeating that the gear was down and locked.

On the approach to the runway, the 2P* enunciated the speeds while the aural warnings were emitted with the heights decreasing from 50 to 20 ft., with the aircraft very close to touchdown. The PIC asked again if the gear was down, and the 2P* reaffirmed that condition.

After touchdown, the PIC criticized his own performance, and the 2P* reported that the climb was positive, asking if that was normal, to which the PIC replied “*somewhat*”.

Thus, it was observed that the checklists for descent, before-landing, and normal landing checks were not read or worked in full. In addition, one verified that the traffic pattern performed was not standard.

<u>Information concerning the flight conducted on 14 September 2021</u>

While starting cabin preparation, the 2P* was informed that the route would direct to SI2F (*Fazenda Tarumã*), instead of the initially planned route for SSZO, (*Aeródromo Santa Marta I*, *Santa Maria das Barreiras*, State of *Pará*). The (Z) flight plan’s ETD from SDPW was 11:00 UTC, and then the aircraft would climb to FL135, with an initial heading toward GERTU fix, where the aircraft would accelerate to 260 kt. and climb to FL280.

The new destination did not significantly affect the planning made by the 2P*, since it was located approximately 14 NM away from the destination initially planned (Figure 25).

Figure 25 - Final section of the initially proposed flight plan, with indication of the new destination. Source: Adapted from SkyVector.

According to reports, the 2P* was the first to arrive at the aerodrome for the flight, and conducted the external inspection of the aircraft (*preflight inspection*), which was described by the ground assistant as a careful and detailed walkaround. The PIC reportedly performed the internal part of this check, related to the cockpit.

Also according to accounts, the aircraft's tanks were filled to their maximum capacity. Seven suitcases were loaded, along with a cooler-type box and other items to be used during the stay, planned to last about seven days.

The basic operational weight of the aircraft was 8,622 lb. (3,910.87 kg), and it was refueled with 3,631.91 lb. (1,647.4 kg) of aviation kerosene (QAV-1). Adding the weight of the crew, passengers, luggage, and the other mentioned items, an estimated takeoff weight of 13,874 lb. (6,293.14 kg) was obtained.

The Maximum Takeoff Weight (MTOW) specified by the aircraft manufacturer was 12,500 lb. (5,667 kg).

Once the passengers embarked, the pilots completed the whole before-taxi checklist, except for the flaps, which the 2P* informed would be verified later. After the brakes were released, the 2P* performed local coordination, and the PIC, acting as Pilot Flying (PF), requested confirmation of runway 35, which was duly ratified by the 2P*.

During taxi, the 2P* enunciated the before-takeoff (runup) checklist items. For the autopilot check, the 2P* asked if they should check the system, and the PIC, in response, authorized him to “skip” it. The same thing was done in relation to the Yaw Damper and Electric Pitch Trim checks.

Upon enunciating the Trim Tabs, the 2P* uttered “*zero, zero, zero,*” indicating that he had checked the three manual trim controls in the neutral position. Then, he mentioned the throttle friction, but it was not possible to determine whether the friction was actually adjusted because the PIC’s voice overlapped with the 2P*’s.

Subsequently, the 2P* checked the flaps and asked if he should leave them in the "*up*" position, receiving confirmation from the PIC. Then, while taxiing to runway 35 of SDPW, the PIC asked the 2P*, "…make some noise?" The 2P* agreed, noting that it would look "better that way." Thus, it was possible to notice a change in the sound profile of the propellers. The PIC added that the mode was "good for taxi," but complained about the noise.

Based on collected data, one inferred that the PIC selected the *ground fine* operation mode, where the power levers were positioned between the minimum limit (*idle stop*) and the reverse range, allowing for variation in the blade angle without altering the rotation in the gas generator (N1).

The 2P* then asked if the PIC would perform the governor and Rudder Boost checks, and received an affirmative answer. The recording confirmed that the governor check reached a maximum of 1,900 RPM. The Rudder Boost check was also considered satisfactory by the pilots, as well as the autofeather check.

On this flight, the 2P* called out and verified the manual prop feathering, completing all the items listed in this section of the checklist. For the takeoff, the 2P* enunciated that he would "turn off the TAWS," suggesting that he would deactivate the system.

According to the findings of the Investigation Committee, this action was taken due to the lack of system update, which would lead it to incorrectly alert about terrain proximity starting from the takeoff in SDPW.

The PIC then suggested that they enter the runway and perform the "before-takeoff" checklist while taxiing. The 2P* confirmed that the propeller levers were fully forward and, once again, that the trim tabs were set to zero.

During the takeoff briefing, the PIC informed that a static takeoff would be performed with flaps up, requesting callouts from the 2P*. He informed that V1 would be 102 kt., VR would be 102 kt, and that they would climb at a V2 of 109 kt.

Upon enunciating the potential malfunctions, the PIC outlined the following situations:

- After takeoff, positive climb and gear up: no action until 400 ft., feathering would be automatic;
- Malfunction above 400 ft.: verify flaps in auto (probably referring to flaps up), first power reduction with a right turn towards GERTU;
- Malfunction below V1: the takeoff would be aborted; and
- Malfunction above V1: if there was runway ahead, the takeoff would be aborted and the stop would take place ahead; if there was no runway, the takeoff would be continued, and they would return via the downwind leg for landing on RWY 35 (same as takeoff runway).

Then, the PIC commented that "despite the rush" (referring to the release of the airplane by the OM, it had "come out just fine," something that was ratified by the 2P*.

After aligning on the runway, the PS-CSM began engine acceleration and rolled down the runway. The 2P* enunciated the speeds, green instruments, V1, and rotation. On the occasion, a stall alert (1 kHz beep) lasting less than 1 second could be heard.

The PIC reported "brakes applied" and requested landing gear retraction. During the retraction, the 2P* mentioned that he would reduce "a little," probably by adjusting the power levers. Subsequently, 20 seconds before the end of the recording, the PIC announced the first power reduction.

The 2P* transmitted that the PS-CSM had taken off from runway 35, and shortly thereafter, an undetermined 500 Hz beep lasting less than half a second was heard. The 2P* asked what had happened, and the PIC replied, "Propeller overspeed."

The 2P* inquired, "Propeller overspeed?" and the PIC calmly confirmed, "Yes."

Following this, the 2P* called on the radio frequency to inform that they would return to the runway, while a stall alert continuous tone (1 kHz) sounded for about 2 seconds. At that point, a single chime (caution) could be heard, followed by the same continuous tone that had just sounded, which continued until the end of the recording.

On that occasion, the 2P* uttered the word "push" seven times, possibly suggesting that the control column be pushed forward. The aural warning "don't sink" could then be heard, which continued to the end of the recording.

The estimated wind at the time of takeoff was 050º at 5 kt. This represented a crosswind component of 3.85 kt., as well as a headwind component of 3.82 kt.

Considering the estimated temperature of 26.5ºC and the described wind information, if the aircraft had a weight of 12,500 lb., its takeoff distance would have been approximately 701 meters, while its accelerate-stop distance would have been 1,158 meters. However, since the weight was 1,374 pounds above the MTOW published by the manufacturer, these distances were no longer applicable.

By means of a video recording made with the cell phone of a witness watching the takeoff near the runway, it was possible to estimate that the aircraft got airborne at a distance of 750 meters from the point where the brakes were released (Figure 26).

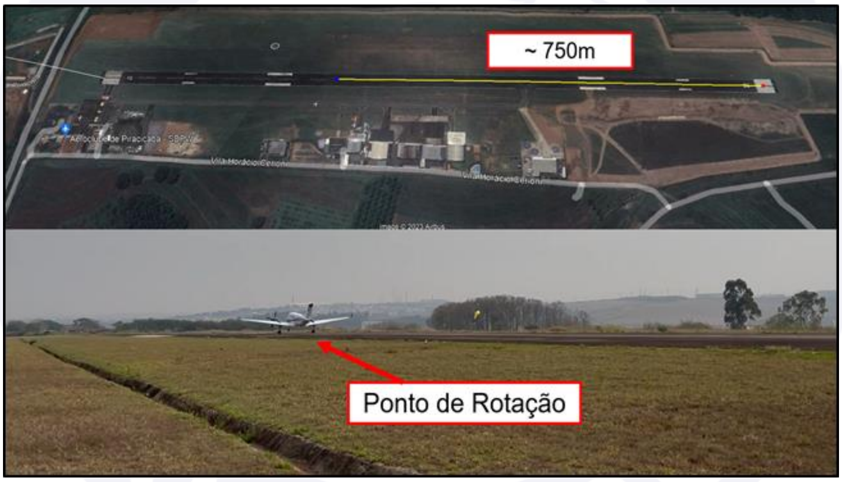


Figure 26 - Estimated distance traveled during the takeoff run.
Source: Adapted from Google Earth and video recording captured by an observer.

Shortly after rotation, the images showed that the aircraft commenced a right turn, which progressively increased until the end of the video, as illustrated in Figure 27, with sequential video excerpts numbered 1 to 4.

Figure 27 - Sequential images of the aircraft during takeoff, progressively ordered in relation to the time of recording

In another video, recorded by a residence security camera system, the aircraft was seen at a 90° angle-of-bank to the right, in a steep descent (Figure 28).

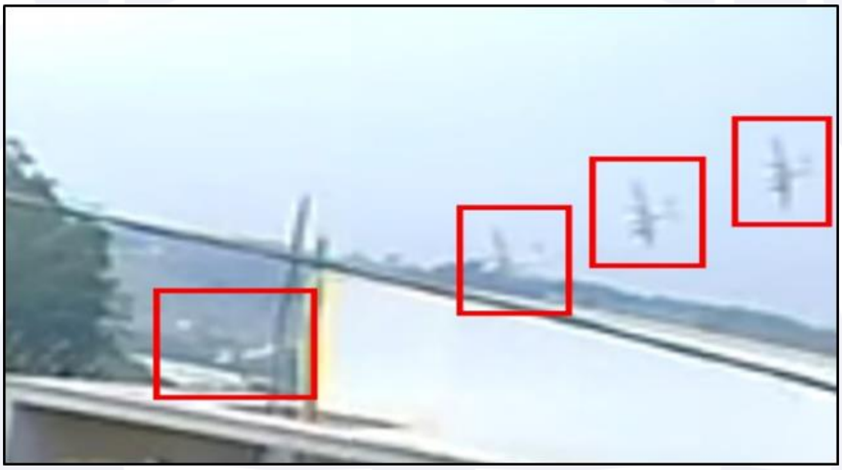


Figure 28 - Aircraft footage captured by a CCTV camera.

The impact occurred about 2,000 meters past the estimated rotation point of the SDPW runway. The impact point was approximately 10° to the right of the takeoff axis, which corroborates the observers' perception that the aircraft appeared to initiate a right turn before rolling onto the corresponding wing and beginning its descent.

As for low-speed warnings and indications, the airplanes equipped with BLR winglets were configured to display the speed range in red, starting at 88 KIAS, with flaps up. The Aircraft Flight Manual (AFM) highlighted that this marking did not replace the stall warning system. However, the AFM warned that a stall condition could occur above this speed under certain weight and altitude conditions, and pilots should consider the limit at which effective directional control was maintained.

The Air Minimum Control Speed (V_{MCA}), representing the minimum speed at which the aircraft was controllable after the loss of the critical engine, while maintaining the parameters of certification, was 86 kt.

The limitations section of the POH/AFM specified N2, or propeller rpm limits, and exceedance times vs. rpm values. There was no propeller overspeed checklist in the POH/AFM or emergency, abnormal, or advisory procedures in the Quick Reference Handbook (QRH) to guide the pilot's action for this situation. The AFM indicated that the flight could continue under propeller overspeed conditions up to 2,120 RPM, provided the torque was limited to 1,800 lb. ft. (Figure 29).

PROPELLER ROTATIONAL OVERSPEED LIMITS

The maximum propeller overspeed limit is 2200 rpm and is time-limited to five seconds. Sustained propeller overspeeds faster than 2000 rpm indicate failure of the primary governor. Flight may be continued at propeller overspeeds up to 2120 rpm, provided torque is limited to 1800 foot-pounds. Sustained propeller overspeeds faster than 2120 rpm indicate failure of both the primary governor and the secondary governor, and such overspeeds are unapproved.

Figure 29 - AFM's description of the propeller overspeed condition.

As for potential visual and aural alarms that could warn the pilots of the overspeed condition, the manual read that if the speed of one of the propellers exceeded 2,040 RPM, the corresponding indicator (N2) would turn yellow, and could become red if this condition persisted for more than 5 seconds. If the RPM remained above 2,000 RPM for more than 300 seconds, the indicator would also turn yellow (Figure 30).

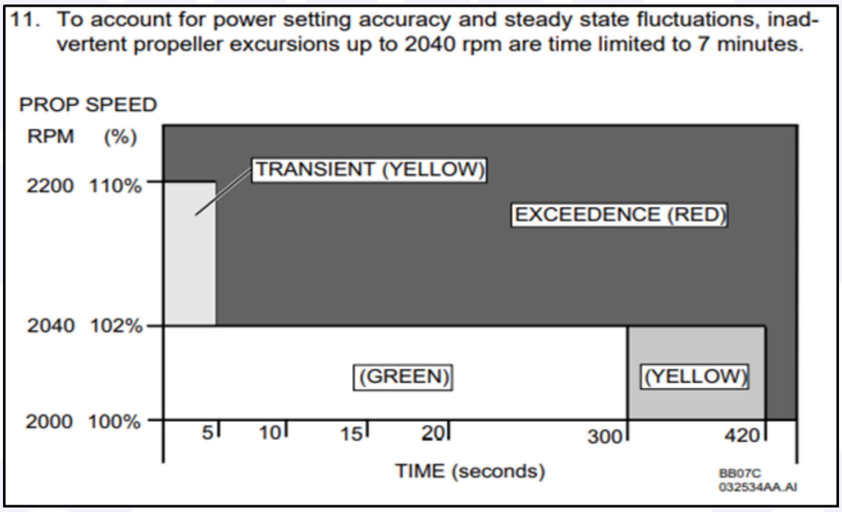


Figure 30 - Alarms and warnings related to the rotation speed of the propellers (AFM).

1.19. Additional information.

<u>Uncommanded Feathering in Hartzell Propellers</u>

The manual for the HC-E4A-3A propellers (61-00-47 ver.1 Nov/02) addressed situations that could lead to the loss of control of such components, including those where uncommanded feathering occurred. Among these, the following stands out:

- Loss of propeller oil pressure, requiring checks of:
    - Pressure relief valve of the governor;
    - Governor drive; and
    - Oil supply.
- *Start lock* not engaging:

This condition was also described in the publication "*Propeller Operation and Malfunctions Basic Familiarization for Flight Crews*", of the "*Commercial Aviation Safety Team*" organization):

> Uncommanded feather is very similar to the overtorque condition (noted above). The propeller pitch will abruptly increase, causing a rapid rise in torque with a rapid drop in RPM, because the engine is still providing power to the propeller. While the pitch is changing, the thrust may increase and then decrease rapidly. The aircraft will have asymmetric thrust. The pilot will need to control the airplane and then shut down the engine. The high torque may cause engine or propeller damage, but it will not, if properly handled, cause loss of control of the airplane.
>
> Source: https://www.cast-safety.org/pdf/4_propeller_fundamentals.pdf

Another situation that could lead to uncommanded feather of propellers in PT6 engines was addressed by the USA's National Transportation Safety Board by means of the Safety Recommendation Report ASR-16-007.

During an investigation conducted by the NTSB, it was found that the beta arm (reverser lever) and related components in PT6A engines could be positioned incorrectly. If the beta arm was not positioned so as to be locked under its guide pin, the insecure connection could release oil pressure at the beta valve and cause uncommanded movement of the propeller toward the feathered position (Figure 31).

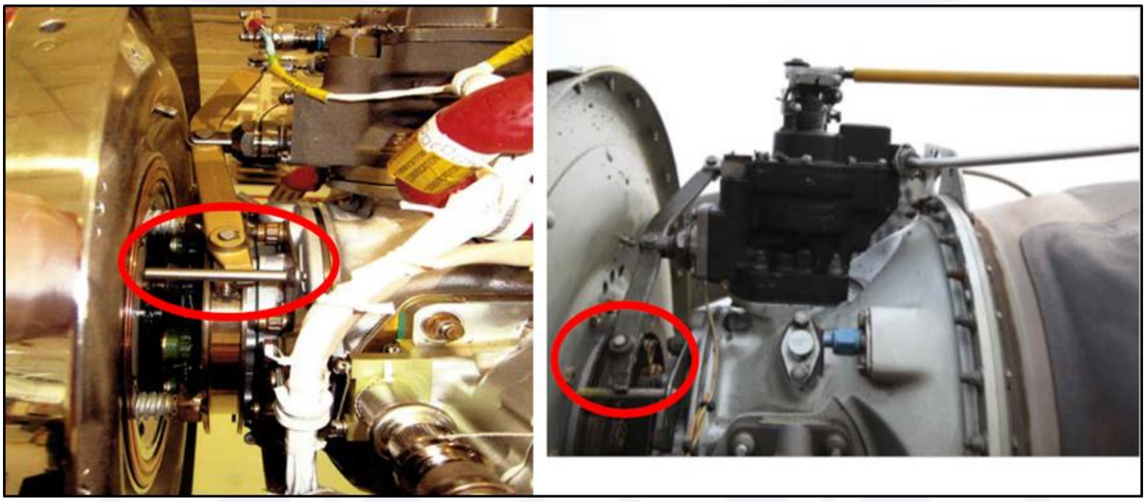


Figure 31 - Examples of correct (on the left) and incorrect (on the right) installation of the beta arm. Source: ASR-16-007, NTSB.

The recommendation was accepted by the Federal Aviation Administration (FAA), which issued the 20002 Safety Alert for Operators (SAFO) on 27 February 2020, establishing actions concerning the PT6A engines.

During the analyses conducted on the engines of the PS-CSM airplane, it was found that both beta arms were in the correct position (Figure 32).

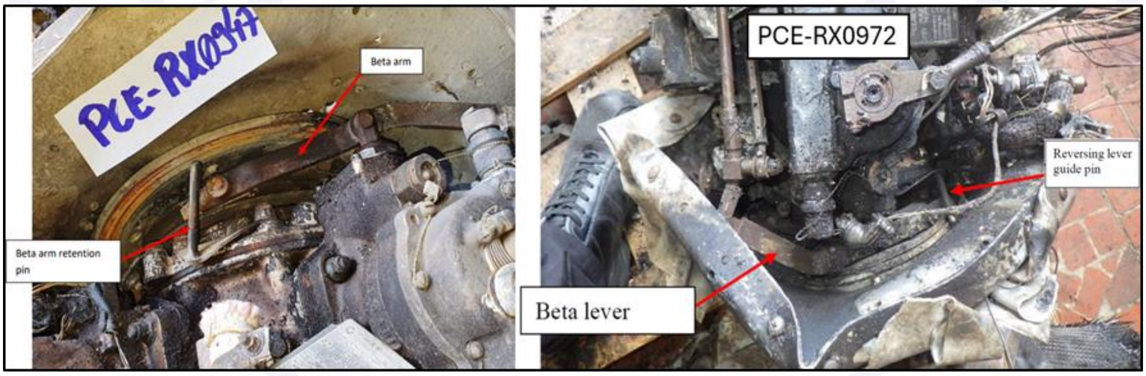


Figure 32 - Positioning of the guide pins in relation to the beta arms on both engines of the PS-CSM airplane.

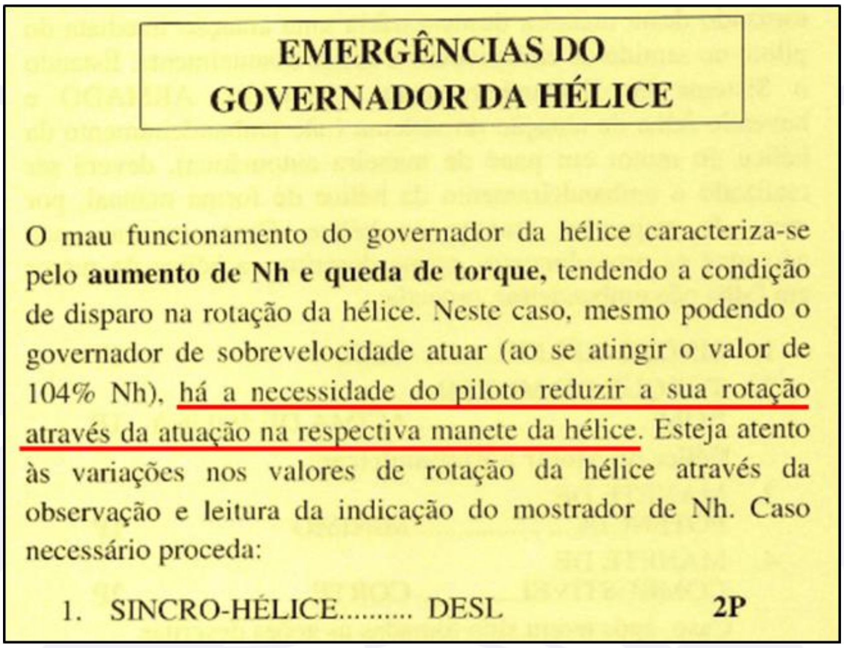
<u>Propeller Governor Emergencies in E110 Aircraft</u>

One verified that the PIC developed much of his experience as captain in E110 aircraft, having flown approximately 1,200 hours in this model between 2011 and 2013.

The E110 *Bandeirante* airplane manufactured by EMBRAER was equipped with PT6A-34 engines, a system that had notable similarities with that of the King Air, particularly in relation to the operation.

Despite the similarities in the propeller control system when compared to the King Air's, the operational publications of the E110 focused on specifying procedures to be followed in case of propeller governor emergencies, such as an overspeed condition.

Upon describing this failure, the QRH of the E110 airplane specified that the pilot needed to reduce the propeller speed by adjusting the respective lever (Figure 33).



EMERGÊNCIAS DO GOVERNADOR DA HÉLICE

O mau funcionamento do governador da hélice caracteriza-se pelo **aumento de Nh e queda de torque,** tendendo a condição de disparo na rotação da hélice. Neste caso, mesmo podendo o governador de sobrevelocidade atuar (ao se atingir o valor de 104% Nh), há a necessidade do piloto reduzir a sua rotação através da atuação na respectiva manete da hélice. Esteja atento às variações nos valores de rotação da hélice através da observação e leitura da indicação do mostrador de Nh. Caso necessário proceda:

1. SINCRO-HÉLICE.......... DESL **2P**

Figure 33 - Propeller Governor Emergency Procedure for the E110 Aircraft.

Negative Transfer Concept

According to an article published in Aviation Week[1], "*negative habit transfer*" can affect the performance of pilots in aviation. This phenomenon occurs when behavior patterns previously learned are inadequate for the current aircraft, environment, or procedures, increasing the risk of human error by five times, according to research by Dr. James Reason.

The article analyzed two fatal accidents, highlighting vulnerabilities in the aviation industry's understanding of this concept. The report of one of the accidents suggested that the common practice of pilots qualified in multiple aircraft could contribute to negative habit transfer, leading to recommendations seeking to review pilot qualification and training practices.

1.20. Useful or effective investigation techniques.

NIL.

2. ANALYSIS.

It was a private flight with the objective of transporting passengers to *Fazenda Tarumã* (SI2F), which belonged to the owner of the PS-CSM airplane.

The airplane was purchased in 2019 and had logged approximately 268 total hours by the time of the accident.

About a year after its nationalization, during a 50-hour inspection, the PS-CSM airplane presented an abnormal increase in RPM upon activation of the automatic feathering, which prompted the first maintenance interventions related to the propellers.

1 VEILLETTE, Patrick. **Negative Habit Transfer Part 1**. Aviation Week, 2021. Available on: https://aviationweek.com/business-aviation/negative-habit-transfer-part-1

A little over three months before the occurrence, the left propeller had to be removed and sent for repair at a certified Maintenance Organization, as two lubrication screws on the left-hand propeller were found to be broken. After the referred propeller was reinstalled, the dynamic balancing of the propellers was performed, and the Beta Valve Carbon Blocks were replaced.

This repair resulted in high costs for the owner, who questioned the OM about whether these costs should be borne by him. Most of the interactions between the OM and the owner were handled by the PIC, and one found that there had been highly stressed situations, which may have contributed to a potential reduction in the PIC's functional performance.

Although the airplane was relatively new, reports obtained by the Investigation Committee indicated that both the owner and the PIC were dissatisfied with the aircraft's dispatchability, with the latter even making negative comments about the frequent "malfunctions" and the governors.

In that respect, it is worth mentioning that the Investigation Committee obtained access to the test records related to the CSU and OSG of both engines. The tests were conducted when these components were delivered new from the aircraft manufacturer, and all parameters were within the specified limits.

Among the maintenance tasks performed between 23 August and 13 September 2021, there were records that both propellers RPM limits were adjusted to correct for discrepancies observed during engine runs.

The maximum rotation, which was previously limited to 1,950 RPM, was adjusted to 1,990 RPM on both sides, as logged in the Power Check Data Worksheet. Additionally, the Flight Idle Low Pitch was also adjusted.

Both the incoming and outgoing inspection forms contained erasures in the notes on the verified parameters, revealing discrepancies in relation to what had been entered in the Service Order corresponding to the maintenance.

It is noteworthy that the Maintenance Organization had scheduled the release of the airplane for 15 September 2021, but the owner attempted to hasten the process in order to meet commitments, and even received a quote from the OM for overtime work in this regard. However, the additional costs were not accepted, and an agreement was made that the services would be completed on Monday morning, two days earlier than originally planned.

It was found that, during the accident flight, the PIC interpreted that a "propeller overspeed" was occurring, which would mean that one of the governors had lost the ability to govern the rotational speed at 2,000 RPM. However, the sound spectrum analysis from the CVR audio identified that there was an overspeed, but the values reached were not sufficient to signal an abnormal condition to the pilots (a change in color on the N2 indicator or a CAUTION warning on the CAS).

This interpretation of the experienced situation may have led to a downgrading in the process of activation of a limited amount of information from the other available data, reducing the possibility of a timely and appropriate response to the likely situation of speed reduction due to the stall warnings emitted.

Therefore, the PIC probably fixated on the excess RPM and did not notice in a timely manner that the indicated airspeed was decreasing, thus limiting the possibility of a prompt response to the stall condition.

One also found that the excess RPM value did not reach the threshold necessary to trigger the overspeed governors, which would only engage at 2,120 RPM.

Although it is not possible to link the overspeed observed during the accident flight to the adjustment made by the Maintenance Organization to achieve higher RPM values, the

Investigation Committee found that the necessary adjustments were labor-intensive and would require several engine runs.

The proposed "early release of the airplane" may have prevented the parameters from being adjusted with the high level of precision required for the task, contributing to the possibility of exceeding the 2,000 RPM limit during a situation of maximum effort, with a power setting above the one allowed by the manufacturer, as occurred during the takeoff of the accident flight.

It was inferred that other effects caused by the early release of the airplane were noticed during the first attempt to start up the engines in SBJD, recorded by the CVR, where the 2P* identified that something had not been properly closed inside the cabin (possibly an access or inspection window), in addition to a defective window in the passenger cabin, which led to shutting down the engines and delaying the planned departure.

Despite that, the pilots did not mention any abnormalities during the flight after the referred adjustments. However, it is worth noting that the governors were not individually checked as required by the manual, but were checked in conjunction with the automatic feather, in such a way that the 2P* could not even follow the verification of the parameters.

Thus, the PIC's rushed execution of the engine checks, in which he reported having checked "*prop gov and autoignition*" instead of "*autofeather*," may not have been sufficient to verify all the parameters.

During the takeoff from SBJD, which would be another opportunity to observe any RPM excess values, the aircraft was lighter and required less power for taking off.

Additionally, the PIC allowed the 2P* to perform the takeoff, something that required a higher level of supervision and attention on the part of the PIC in relation to the controls, leading both pilots to focusing on a variety of flight parameters.

It is important to note that this was a flight conducted after a major inspection, where it would have been desirable for all checks to be performed with greater attention, something that was not observed in the CVR recordings.

Notwithstanding, during the accident flight, the operation of the governors and overspeed governors was properly tested, and according to the pilots' callouts, the parameters were reached during the check.

Although the excessive RPM became part of the chain of events leading to the accident, the values reached were not sufficient to affect the directional control of the aircraft, provided that the takeoff torque had been achieved and maintained during that phase of the flight.

On the accident flight, immediately after retraction of the landing gear, the 2P* informed that he was slightly reducing the power. Then, the PIC said "first reduction," probably making further adjustments to the corresponding throttles. The continuous 1 kHz tone, associated with a stall condition, started exactly 13 seconds later, followed by the feathering of the right-hand propeller and loss of control of the aircraft.

In terms of perception, the recordings revealed that the PIC focused on the excessive RPM condition, with no evidence that he recognized the pre-stall characteristics.

The 2P*, in turn, repeatedly uttered the word "*push*," indicating that he had recognized the condition and was suggesting that control inputs be applied to recover the aircraft. The reason for using the term in English could be attributed to the fact that he conducted cockpit checks in that language and had completed part of his aviation training in the United States.

The excess of 1,374 pounds above the maximum published takeoff weight during takeoff was also a factor that influenced the accident dynamics. Both the torque and speed, as well as the other parameters known and applied by the pilots were within the 12,500-pound limit specified by the manufacturer and available in various sections of the AFM.

As verified, the owner had considerable confidence in that airplane, to the point of stating that it would be capable of taking off with just one engine. This belief may have contributed to the PIC not having restricted him in relation to the weight limit of the items that could be loaded on that flight and on previous ones.

Furthermore, there was some anxiety for that flight to take place, given the amount of time the aircraft had spent in maintenance.

The PIC had accumulated extensive experience as a commander of multi-engine aircraft and had more operating time in the PS-CSM airplane than the 2P*, as he had been responsible for overseeing the aircraft’s ferry flight from the country of origin. At that time, he also underwent simulator training for that aircraft.

However, there were no records indicating that the PIC had undergone emergency training in this aircraft model since September 2015, the date of the last revalidation of his BE20 type rating.

Such situation arose from the fact that the aircraft was reclassified as MLTE Class, according to the new instructions contained in the IS 61-004G, and the endorsement requirement was limited to including the aircraft in the pilot’s digital logbook, without the need for any specific training on the model, as long as the MLTE rating remained valid, which was the case.

In the period the aircraft was classified as “type,” the rating was valid for one year, and every twelve months, pilots were required to undergo a type rating revalidation process for that specific aircraft model.

From 2019 until December 2020, the PIC operated the PS-CSM airplane in a “single pilot” condition, as allowed by the certification. The inclusion of a second pilot had the aim of enhancing the safety of the operation.

The time length in which they did not operate the aircraft, combined with the low frequency of flights before the maintenance began, likely led both pilots to evaluate their own piloting performance with some dissatisfaction during that flight, as mentioned by them on a number of occasions.

It was observed that, during the flight on the day before the accident, the pilots had difficulty locating SDPW, an aerodrome where they operated with reasonable frequency. It was also noted that the PIC showed some inattention, since after requesting the lowering of the landing gear and hearing confirmation from the 2P*, he again asked about the landing gear status. Even after two further confirmations from the 2P*, the PIC questioned the condition anew after the aural warning indicated an altitude of 20 feet above the runway.

As already mentioned, it is possible that the inattention resulted from stress related to his recent problems dealing with the maintenance team, combined with the pressure he experienced in his efforts to expedite the aircraft's release and conduct that flight.

These factors may also be related to the reduction of the PIC's situational awareness during the event, as his attention shifted to the excess RPM, but the imminent stall condition was not perceived.

The aircraft's takeoff weight was estimated to be 1,374 pounds (623.24 kg) above the MTOW allowed by the manufacturer, which made it impossible to accurately plan the takeoff distance, speeds, and other operational parameters.

In this context, one found that the PIC utilized a rotation speed of 102 kt., which was the speed relative to the Maximum Take-Off Weight (MTOW). However, since the aircraft was above the MTOW, rotating the aircraft at 102 kt. triggered a continuous 1 kHz alarm, indicating that the aircraft had entered a pre-stall condition.

According to collected data, operating the aircraft above its weight limit was common among some operators, due to the belief that the restriction was not related to structural or performance limitations. Therefore, such culture may have contributed to the PIC’s decision to operate under those conditions.

The repeated behavior of not performing checks, which was also observed during the flight of the previous day, may be related to overconfidence, which reduced the safety margins of the operation.

Relatively to the feathering of the right-hand propeller, the examinations showed that it occurred under a moderate to high power condition, corroborating the results of the engines’ analyses, which indicated that both engines were producing power at the moment of impact.

The failure conditions that would lead to an inadvertent feathering in flight, such as potential failure of the governors, were ruled out after the analyses of these components, which showed no pre-existing conditions capable of preventing their normal operation.

The hypothesis of incorrect positioning of the beta arm or Beta Valve Carbon Block was also ruled out, as these components were verified during the analysis.

The time taken by the propeller to feather, between 4 and 5 seconds, also allowed to rule out the hypothesis of improper friction adjustment on the levers, which could have caused them to “slip” toward reduction.

Therefore, the hypothesis that remained was that the feathering was commanded by the PIC, as he informed the 2P* that the aircraft had entered a “propeller overspeed” condition.

Furthermore, according to analyses of the sound spectrum, the aircraft did not reach RPM values consistent with a “propeller overspeed” condition, as described by the manufacturer’s specifications.

According to examinations conducted, it was concluded that the right-hand propeller was in the process of feathering. A possible feathering command may have precipitated the loss of control of the aircraft.

Despite the propeller overspeed condition or situation was not included in the B200GT's QRH, much of the PIC’s professional experience was in multiengine aircraft, such as the E110 *Bandeirante*, which required propeller lever actions to handle emergencies related to the governor.

Considering that this procedure was not trained by the PIC on the B200GT, the hypothesis was raised that such procedures may have originated from the PIC's memory resources, as a result of “negative transfer,” since they were trained on other aircraft.

Moreover, the inclusion of the aircraft in the “Class” category by the Regulatory Agency may have influenced the level of pilot training on that model, limiting their ability to distinguish situations related to propeller rotation above 2,000 RPM.

The reduction of training requirements proposed in the IS nº 61-004, updated in 2016, relaxed the requirements for operating the aircraft, which came to depend solely on the endorsement of a qualified pilot.

Finally, it is noteworthy that there was no checklist for propeller overspeed in the aircraft's Quick Reference Handbook or the Pilot’s Operating Handbook and FAA Approved Airplane Flight Manual. The lack of any mention of the crew’s need to refrain from taking action in overspeed conditions, however, may have contributed to the attempt to control the rotational speed by means of the propeller levers.

3. CONCLUSIONS.

3.1. Findings.

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

b) the pilots held valid ratings for MLTE (Multi-Engine Land Airplane) and IFRA (IFR Flight - Airplane);

c) the PIC was qualified and had experience in the type of flight;

d) the 2P* did not have an endorsement to operate B200GT aircraft;

e) the B200GT could be operated by a single pilot on the event flight;

f) the aircraft had a valid CVA (Airworthiness-Verification Certificate);

g) the aircraft weight was 1,374 lb. (623.24 kg) above the Maximum Takeoff Weight (MTOW) specified by the manufacturer;

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

i) the weather conditions were above the minima for the flight;

j) the aircraft had modifications related to performance, with winglets added to the wings and metal propeller blades replaced with structural composite blades, as per specific Supplemental Type Certificates (STC);

k) during an inspection of the aircraft performed on 19 April 2021, two left-hand propeller lubrication screws were found to be broken;

l) on 23 April 2021, the PN HC-E4N-3A / SN NR511 left-hand propeller, with a total 227 hours and 6 minutes of operation, was removed and sent for external repair;

m) after returning from the external OM, the left-hand propeller was installed and submitted to dynamic balancing;

n) the latest and most comprehensive inspection of the aircraft (“365 Days/CVA obtainment” type) began on 23 August 2021 and ended on 13 September 2021;

o) in the latest inspection, the Flight Idle low pitch and propeller speed limit parameters were adjusted close to the maximum rpm value of 2,000 rpm;

p) there were erasures in the Power Check Data Worksheet records relating to the adjustments made to the turboprop assembly parameters;

q) the flight conducted after the aircraft release on 13 September 2021 was delayed after detection of a failure in the system of one of the passenger-cabin windows;

r) during the taxi in SBJD on 13 September 2021, the governor and overspeed governor checks were performed in disagreement with the provisions of the aircraft operating manual, and were not understood by the 2P*, who was not qualified in the airplane;

s) the takeoff from SBJD on 13 September 2021 was made by the 2P* under the PIC’s supervision, with 1,374 pounds above the published Maximum Takeoff Weight (MTOW);

t) the aircraft's fuel tanks were filled to the limit of their capacity;

u) during the “before-takeoff (runup) checklist”, the trim tabs were confirmed to be in the “zero” position;

v) the flaps were left in the “up” position for takeoff;

w) while working the “before-takeoff (runup) checklist”, the check items for the governors, overspeed governors, rudder boost, and automatic feathering were verified;

x) during the rotation of the aircraft, a continuous 1 kHz audible alarm associated with the aircraft stall warning was heard;

y) after retraction of the aircraft's landing gear, the PIC announced "propeller overspeed";

z) the 2P* uttered the word "push" seven times, possibly suggesting that the control column be pushed forward;

aa) the analysis of the aircraft's engines concluded that both exhibited signatures characteristic of operation at the time of impact;

bb) the impact signatures on the notches of the left propeller forks indicated that it was operating at an RPM that was higher in comparison to the right propeller;

cc) the analysis conducted on the right propeller hub indicated that the blades were operating within a range from 60° to 78° at the time of impact, indicative of a feathering process;

dd) during the analysis of the propellers, no discrepancies were observed that could have prevented or degraded their normal operation prior to the impact with the ground;

ee) the analyses conducted on the CSU and OSG of both engines indicated that there was no evidence of any pre-existing condition that could have prevented the normal operation of the governors;

ff) the analyses of the CVR's audio spectrum indicated that there was an increase in propeller speed to 2,025 RPM over a 4-second interval;

gg) according to analyses of the CVR's audio spectrum, the propellers' speed reduced to 1,830 RPM approximately 12 seconds before impact;

hh) approximately 7 seconds before the impact, a continuous 1 kHz alarm associated with the aircraft's stall detection system was triggered;

ii) the analysis of the propellers and the CVR's audio spectrum indicated that the right propeller feathered approximately 4 seconds before impact;

jj) the aircraft rolled onto its right wing and entered a steep descent, triggering the "don't sink" and "pull-up" warnings;

kk) the aircraft was destroyed upon impact; and

ll) all the occupants of the aircraft sustained fatal injuries.

3.2. Contributing factors.

- **Attention - a contributor.**

The analysis of the pilots' performance during the flight of the previous day revealed episodes of inattention, such as those related to the lowering of the landing gear. In the accident flight, the crew fixated on the excessive RPM, failing to notice in a timely manner that the speed was decreasing, something that limited their ability to promptly respond to the stall condition.

- **Attitude - a contributor.**

During the accident flight, it was noted that the aircraft rotated at a speed of 102 knots, being such speed consistent with the prescribed aircraft's maximum takeoff weight. However, because the aircraft's weight was 1,374 pounds above the MTOW, when it rotated at the referred speed, a continuous 1 kHz alarm sounded, indicating that it had entered a pre-stall condition. Such improvisational approach regarding the MTOW exacerbated the situation, contributing to the outcome of the accident.

- **Training - undetermined.**

The classification of the aircraft by the Brazilian Regulatory Agency as a “class aircraft” may have contributed to the training required from pilots being insufficient to ensure their proficiency in handling emergencies on the B200GT aircraft.

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

According to reports, the belief that the King Air aircraft was capable of taking off with a weight greater than the one specified by the manufacturer was common among operators to whom the investigators had access. This belief may have contributed to the decision made to conduct the flight under those conditions, influencing the takeoff performance.

- **Handling of aircraft flight controls - undetermined.**

After the retraction of the landing gear, a command to reduce aircraft power was applied by the PIC, which preceded the stall warning. Following this warning, a possible command for feathering one of the propellers may have triggered loss of control of the aircraft.

- **Piloting judgment - a contributor.**

The takeoff in which the accident occurred was performed 1,374 pounds above the weight limit prescribed in the AFM. Speeds and parameters of a typical takeoff were used, with power being reduced shortly after the landing gear retraction. In this context, there was no adequate assessment of the flight parameters, culminating in the aircraft’s stall condition.

- **Aircraft maintenance - undetermined.**

Although one engine N2 maximum of 25 RPM greater than the Takeoff and Max Continuous value of 2,000 RPM verified at takeoff cannot be directly linked to the adjustments made to the propellers during the last inspection, the early release of the aircraft may have prevented a sufficiently thorough check of the maintenance tasks performed. This was found to have occurred the day before the accident after the first attempt to start up the engines. There were erasures on the record sheet that documented the engine parameters at entry and exit, leading to discrepancies in relation to the records made in the corresponding Service Order.

- **Memory - undetermined.**

The analysis of the Cockpit Voice Recorder’s audio spectrum revealed that the propellers were adjusted after the “propeller overspeed” callout was made by the PIC. Although this procedure was not prescribed for the B200GT, it was found to be practiced in the E110 aircraft, in which the PIC had developed much of his professional experience. It is possible that this action originated from the retrieval of previous conditionings, characterizing what is known as “negative transfer”.

- **Perception - a contributor.**

The stall condition, likely related to the gradual reduction in speed that followed the reduction of the power levers, was not perceived in a timely manner for a reaction to be planned. In that context, there was exclusively a perception of the slightly excessive propeller RPM, a maximum amount of 25 RPM, which impaired the situational awareness regarding the other aspects of the flight.

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), it is recommended:

A-104/CENIPA/2021 - 01 **Issued on 02/13/2025**

Analyze the feasibility of establishing an expiration date for endorsements issued for specific Class aircraft models, such as the B200, in order to ensure that pilots undergo a refresher process on these aircraft models, which were considered Type aircraft before the publication of Amendment 06 to RBAC-61.

5. CORRECTIVE OR PREVENTATIVE ACTION ALREADY TAKEN.

None.

On February 13th, 2025.