COMANDO DA AERONÁUTICA

CENTRO DE INVESTIGAÇÃO E PREVENÇÃO DE ACIDENTES AERONÁUTICOS

FINAL REPORT
A-063/CENIPA/2022

OCCURRENCE:	**ACCIDENT**
AIRCRAFT:	**PT-OQR**
MODEL:	**208**
DATE:	**11MAI2022**

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 Final Report pertains to the May 11, 2022 accident involving the model 208 Cessna aircraft of registration marks PT-OQR. The occurrence was typified as “[SCF-PP] Powerplant failure or malfunction.”

The aircraft experienced loss of power and performed an emergency landing in a rural area, during which it overturned.

The aircraft sustained substantial damage.

Two passengers suffered fatal injuries; the pilot and four passengers were seriously injured; four passengers were slightly injured; and five passengers sustained no injuries.

Being the USA the State of design and manufacture of the aircraft, an accredited representative from the National Transportation Safety Board (NTSB) was appointed for participation in the investigation of the accident.

Being Canada the State of design and manufacture of the engine, an accredited representative from the Canadian Transportation Safety Board (TSB) was designated for participation in this investigation.

TABLE OF CONTENTS

GLOSSARY OF TECHNICAL TERMS AND ABBREVIATIONS

ANAC	Brazil's National Civil Aviation Agency
CENIPA	Brazil's Center for the Investigation and Prevention of Aeronautical Accidents
CMA	Aeronautical Medical Certificate
CIV	Digital Pilot-Logbook
CST	Supplemental Type Certificate
DECEA	Brazil's Command of Aeronautics' Department of Airspace Control
EPL	Emergency Power Lever
FCU	Fuel Control Unit
FOD	Foreign Object Debris/Damage
HSI	Hot Section Inspection
IFRA	Instrument Flight Rating – Airplane
IS	Supplemental Instruction
ITT	Interstage Turbine Temperature
LPQD	Parachute Drop Pilot Qualification (as per Brazilian Regulations)
MGSO	Brazilian equivalent for SMM – Safety Management Manual
MNTE	Single-Engine Landplane Rating
OM	Maintenance Organization
PCM	Commercial Pilot License - Airplane
PIC	Pilot in Command
PN	Part Number
POH	Pilot´s Operating Handbook
PPR	Private Pilot License
PSO-BR	Civil Aviation Safety Program - Brazil
RBAC	Brazilian Civil Aviation Regulation
SDOI	ICAO location designator - *Centro Nacional de Paraquedismo* Aerodrome, *Boituva*, State of *São Paulo*.
SIC	Second in Command
SIPAER	Brazil's Aeronautical Accidents Investigation and Prevention System
SN	Serial Number
TSN	Time Since New
UTC	Coordinated Universal Time

1. FACTUAL INFORMATION.

Aircraft	**Model:** 208 **Registration:** PT-OQR **Manufacturer:** Cessna Aircraft.	**Operator:** Skydive4fun *Serviço Aéreo Especializado Ltda.*
Occurrence	**Date/time**: 11MAI2022 - 15:05 (UTC) **Location:** Rural area of *Boituva* **Lat.** 23°18’34”S **Long.** 047°42’36”W **Municipality – State:** *Boituva – São Paulo.*	**Type(s):** [SCF-PP] Powerplant failure or malfunction

1.1. History of the flight.

At approximately 1500 UTC, the aircraft took off from SDOI (*Centro Nacional de Paraquedismo* Aerodrome, municipality of *Boituva*, in the State of *São Paulo*) for a local parachute drop flight, with one pilot and fifteen passengers on board.

During climbout, the aircraft sustained loss of engine power. The pilot performed an emergency landing in a rural area.

Upon landing, the aircraft collided with an embankment and a fence, and eventually overturned.

Figure 1 – Aircraft shortly after the occurrence.

1.2. Injuries to persons.

Injuries	Crew	Passengers	Others
Fatal	-	2	-
Serious	1	4	-
Minor	-	4	-
None	-	5	-

1.3. Damage to the aircraft.

The aircraft sustained substantial damage.

The nose landing gear detached. There was damage to the powerplant assembly, fuselage, wings, and empennage. The engine mount separated from the aircraft, and the engine assembly rotated 90° relative to the longitudinal axis.

The wings sustained damage to the leading edges, lower and upper surfaces, as well as to their control surfaces.

The fuselage ended up slightly wrinkled, and the vertical surface of the empennage was destroyed.

1.4. Other damage.

There was damage to a barbed-wire fence, which was broken during the landing, and a local telephone line was also affected.

1.5. Personnel information.

1.5.1. Crew's flight experience.

HOURS FLOWN	
	PIC
Total	2,712:39
Total in the last 30 days	51:31
Total in the last 24 hours	05:10
In this type of aircraft	1,861:01
In this type in the last 30 days	51:31
In this type in the last 24 hours	05:10

Note: data on the hours flown obtained from the Digital Pilot-Logbook (CIV).

1.5.2. Personnel training.

The Pilot in Command (PIC) did his PPR course (Private Pilot – Airplane) in January 2011, at the *Aeroclube de Piracicaba,* State of *São Paulo*. He earned his PCM license (Commercial Pilot – Airplane) in April 2012 and his INVA rating (Flight Instructor – Airplane) in September 2012.

1.5.3. Category of licenses and validity of certificates.

The PIC held a PCM license and valid ratings for MNTE (Single-Engine Land Airplane) and IFRA (Instrument Flight – Airplane).

1.5.4. Qualification and flight experience.

On November 15, 2016, the PIC received training for obtainment of initial authorization to perform parachute drop operations.

According to his CIV, the first flight in Cessna 208 aircraft took place on February 23, 2018. Therefore, he had been operating this aircraft model for over four years.

As for his LPQD rating (Parachute Drop Pilot), following the publication of Amendment 08 to the Brazilian Civil Aviation Regulation nº 61 (RBAC-61), effective June 8, 2018, his rating was revoked and replaced by an endorsement authorizing such operations, as established in sections 61.31(g) and (h) of the RBAC-61.

The endorsement was regulated by the Supplementary Instruction (IS) 61-006, as per the following text:

> Transition rule:
>
> Pilots who held the Parachute Drop Pilot rating, which was revoked with the enactment of Amendment 08 to RBAC nº 61, are considered endorsed to perform parachute drop operations.

The Investigation Committee concluded that the pilot was qualified and experienced in the type of flight.

1.5.5. Validity of medical certificate.

The PIC held a valid CMA (Aeronautical Medical Certificate).

1.6. Aircraft information.

The aircraft (Serial Number 20800219) was manufactured by Cessna Aircraft in 1992, and registered under the SAE-PQD category (Public Specialized Air Service – Parachute Operations).

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

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

The most recent inspection ("200-hour or annual" type) of the aircraft was performed on March 11, 2022, on the premises of the maintenance organization *CONAL AVIONICS* (COM 9012-08/ANAC), in *Sorocaba*, State of *São Paulo*. At the time of the occurrence, the aircraft had accumulated 98 hours and 48 minutes of flight after the referred inspection.

The most recent comprehensive inspection of the aircraft, required for issuance of the CVA, had been carried out on September 16, 2021, also on the premises of *CONAL AVIONICS* (COM 9012-08/ANAC), and the aircraft flew 221 hours and 24 minutes after the said inspection.

Most of the maintenance actions performed on the aircraft from May 2017 onward — including inspections for CVA and Annual Maintenance Inspection (IAM), as well as scheduled and unscheduled maintenance tasks — were also carried out by *CONAL AVIONICS* (COM 9012-08/ANAC).

The aircraft's airframe had a total of 9,530 hours and 36 minutes of flight time, while its Pratt & Whitney PT6-42A engine (SN PCE-RM0557) had a total of 3,526 flight hours.

Regarding the engine installed on the aircraft, the following maintenance time line was noted:

- On December 18, 2013, the engine in question was installed on the aircraft and underwent inspections in accordance with the manufacturer's recommended schedule;
- On December 10, 2014, with an engine Time Since New (TSN) of 940 hours, the Fuel Control Unit (FCU) malfunctioned and had to be replaced with another FCU, which had a TSN of 266 hours;
- After 119 hours of operation, the replacement FCU also presented malfunctions and had to be replaced with a third FCU on January 31, 2015;
- On February 7, 2015, with a TSN of 1,059 hours and 24 minutes, the aircraft experienced further issues with the fuel system and underwent unscheduled maintenance, which included the removal and testing of the following engine components: FCU, fuel pump, and replacement of the Flow Divider. Additionally, 14 fuel nozzles were replaced;
- On March 13, 2015, with a TSN of 1,114 hours and 30 minutes, the engine was removed from the aircraft and sent to Pratt & Whitney Engine Services, Inc. (COM 9907-07/ANAC), for inspection of the engine's hot section. No engine components were replaced during this maintenance action;
- On September 19, 2017, with a TSN of 2,042 hours, a borescope inspection of the engine's hot section was performed by Air Turbine Aviation company (COM 0903-41/ANAC), during which burn marks, erosion, and material loss were found on the cooling rings, with measurements exceeding acceptable limits on the outer liner of the combustion chamber. Additionally, erosion, material loss, and cracking beyond permissible limits were identified on the small duct. A Hot Section Inspection (HSI) and/or replacement of the affected parts was recommended;

- On October 6, 2017, with a TSN of 2,049 hours and 36 minutes, the engine was removed and sent to *Pratt & Whitney Canada do Brasil* (COM 0002-03/ANAC) for the HSI, during which the compressor stator assembly was replaced;
- On October 28, 2019, with a TSN of 2,989 hours, a borescope inspection of the engine's hot section revealed the presence of cracks on both the inner and outer liners of the engine's combustion chamber, as illustrated in Figures 2 and 3 of the technical report issued by *Pratt & Whitney Canada do Brasil*.

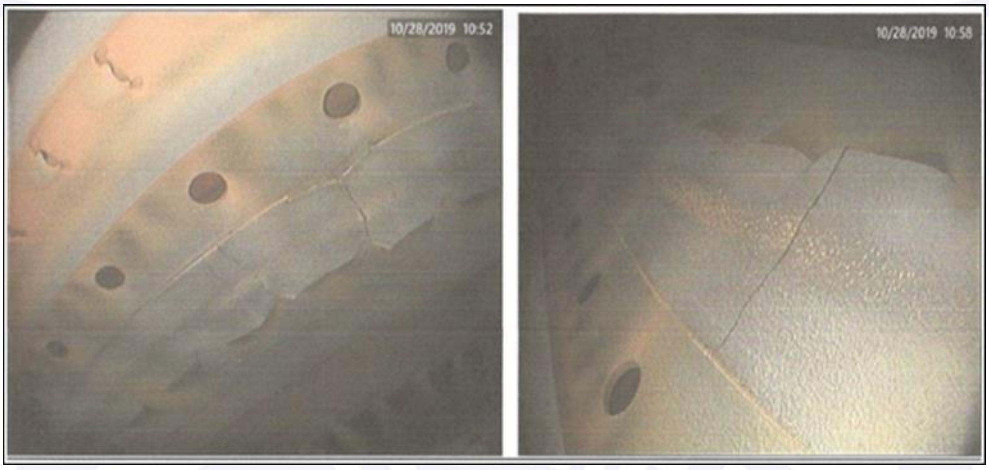

Figure 2 – Borescopic image of the outer liner of the engine's combustion chamber on October 28, 2019.

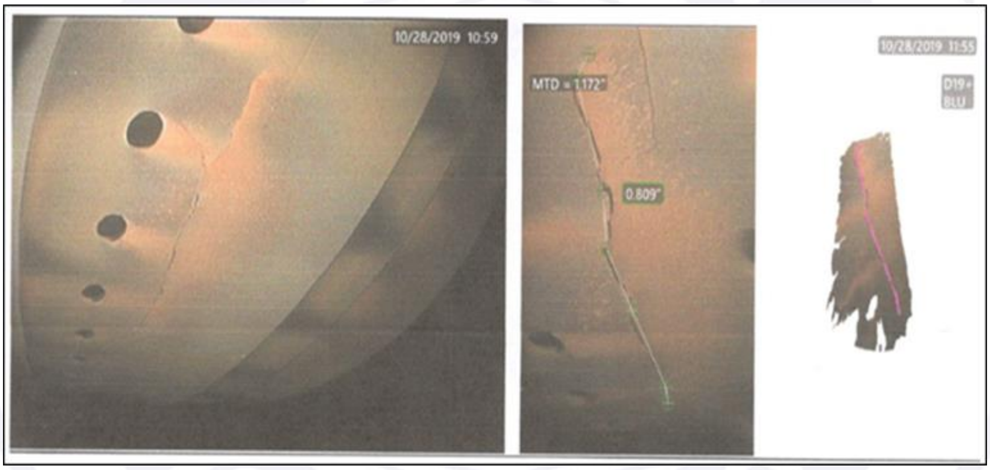

Figura 3 - Borescopic image of the inner liner of the engine's combustion chamber on October 28, 2019.

- On December 17, 2019, with a TSN of 3,017 hours and 36 minutes, the inner liner and outer liner of the engine's combustion chamber were replaced;
- On March 23, 2020, with a TSN of 3,092 hours and 18 minutes, the aircraft engine was removed and sent to *Pratt & Whitney Canada do Brasil* for inspection, during which repairs were performed on the compressor stator and an engine test bench run was conducted;
- On June 18, 2021, with a TSN of 3,218 hours and 36 minutes, a borescope inspection was performed on the engine by *CONAL AVIONICS*, during which the presence of cracks in the combustion chamber was identified, along with burn marks, erosion, and material loss in some stator blades (Figure 4). The investigation team was not provided with the corresponding inspection report, and it was not entered into the aircraft's logbooks;

Figure 4 – Cracks in the combustion chamber and burn marks, erosion, and material loss in a compressor stator blade.

- On September 16, 2021, with a TSN of 3,304 hours and 36 minutes (86 flight hours after the previous borescope inspection), another borescope inspection was conducted by *CONAL AVIONICS*. It is noteworthy that the report of this inspection was also not provided to the investigation team, nor was it entered into the aircraft's logbooks;
- On December 14, 2021, with a TSN of 3,316 hours and 24 minutes, the aircraft underwent maintenance for troubleshooting of a compressor stall at *CSA – Centro de Serviços Aeronáuticos Ltda.* (COM 1303-61/ANAC), where general repairs and adjustments were performed on the engine. The following components were replaced: compressor turbine stators, combustion chamber inner liner, combustion chamber outer liner, spacer oil slinger, 36 second-stage compressor blades, 36 third-stage compressor blades, and both bleed valves. A performance check on a test bench was also performed;
- On January 6, 2022, with a TSN of 3,328 hours and 48 minutes, the engine's FCU was replaced by *CONAL AVIONICS*. A unit with a TSN of 3,909 hours and 54 minutes was installed, and a pre-purchase inspection of the aircraft was also carried out;
- Finally, on March 10, 2022, with a TSN of 3,427 hours and 12 minutes, the engine was removed for a test bench run at *CSA – Centro de Serviços Aeronáuticos Ltda.*, during which the Gearshaft Drive of the Accessory Gearbox and the Wiring Harness were replaced.

With regard to the scheduled maintenance of the FCU manual override system, the Pratt & Whitney Canada maintenance manual, Part Number (PN) 3021442, requires that for aircraft equipped with this system — such as PT-OQR — a static check of the FCU manual override must be performed every 200 flight hours.

In this sense it was confirmed that this maintenance was performed in accordance with the manufacturer's guidelines since the installation of the engine on the aircraft.

As for the aircraft logbook, there were no entries from pilots regarding discrepancies observed in flight.

Regarding throttle operation, this engine was normally controlled via a Power Lever, a Propeller Control Lever, and a Fuel Condition Lever. In addition to the mentioned levers, the aircraft was also equipped with an Emergency Power Lever (EPL), which was used for manual override of the FCU (Figure 5).

Figure 5 – Throttle quadrant of the PT-OQR after the accident, highlighting the EPL.

The EPL was a safety component installed on some turboprop-powered aircraft, such as the PT-OQR. Its primary function was to provide manual control of the engine's fuel flow in emergency situations when the automatic control was unavailable or had failed.

The Pilot's Operating Handbook (POH) provided the following information regarding the use of the EPL:

> ***EMERGENCY POWER LEVER (Continued)***
>
> *Operation of the EMERGENCY POWER Lever is prohibited with the primary power lever out of the IDLE position. The EMERGENCY POWER Lever overrides normal fuel control functions and results in the direct operation of the fuel metering valve. The EMERGENCY POWER Lever will override the automatic fuel governing and engine acceleration scheduling controlled during normal operation by the primary power lever.*
>
> ***CAUTION***
>
> *Inappropriate use of the EMERGENCY POWER Lever may adversely affect engine operation and durability. Use of the EMERGENCY POWER Lever during normal operation of the power lever may result in engine surges, or exceeding the ITT, NG, and torque limits.*
>
> ***CAUTION***
>
> *The EMERGENCY POWER Lever and its associated manual override system are considered to be an emergency system and should be used only in the event of a fuel control unit malfunction.*

Regarding the aircraft configuration, on June 20, 2011, its airframe underwent a major modification, which consisted in the conversion of the aircraft for transport and drop of parachutists operations.

As part of this modification, the following components were installed on the exterior of the aircraft: a step, handrail, external handles on the left side, and a sliding door with vertical opening capability.

Inside the cabin, the following items were installed: handrails, a static line retention strap, indicator lights for the drop phases, instructional placards, and fourteen seat belts for parachutists seated on the cabin floor (Figure 6).

Modificação da configuração interna da aeronave para o transporte e lançamento de paraquedistas, de acordo com a Lista Mestra dos Documentos Técnicos No. JNP/OQR-1010, Rev. 2, de 10 jan. 2011, conforme abaixo:

1 - Instalação de estribo, balaústre e alças externas do lado esquerdo.

2 - Instalação de porta corrediça para abertura na vertical.

3 - Instalação no interior da cabine de corrimãos, alça para retenção das "static lines", lâmpadas de indicação das fases de lançamento, placares com instruções e quatorze (14) cintos de segurança para paraquedistas sentados no assoalho.

Figure 6 – Description of the work performed during the major airframe modification (SEGVOO 001).

Although the cabin had only 14 seat belts for parachutists, the front right seat was made available for parachutists as well, allowing the carriage of up to 15 parachutists plus one pilot on board, as shown in Figure 7, from Supplement H.20-1587-0/ANAC/2011 of the aircraft flight manual, issued on June 20, 2011.

"O NÚMERO MÁXIMO DE OCUPANTES É
DE UM PILOTO E QUINZE PARAQUEDISTAS"
"É OBRIGATÓRIO O USO DE CINTO DE SEGURANÇA
POR TODOS OS OCUPANTES"

Figure 7 – Mandatory signage to be installed on the aircraft, as per flight manual supplement H.20-1587-0/ANAC/2011.

The installation of the parachute drop system was performed in accordance with the Master List of Technical Documents JNP/OQR-1010, dated October 10, 2010.

No records of this major modification/repair for the adaptation of the aircraft to parachute operations were found in Part III of the airframe logbooks.

After that date, no further administrative procedures were carried out to modify the aircraft configuration. The only record found in the ANAC's database was the process H.20-1587-0, which refers to the initial modification of the aircraft for parachute operations.

During the accident flight, it was observed that PT-OQR was configured with two longitudinally oriented benches for parachutists, as shown in Figure 8.

Figure 8 – Internal configuration of the aircraft for the transport and drop of parachutists during the accident flight.

There was only one seat available for the pilot, and no seat was installed in the Second in Command (SIC) position.

Furthermore, it was observed that the parachutists' seat belts were attached to the aircraft floor on only one side of the benches, as shown in Figure 9.

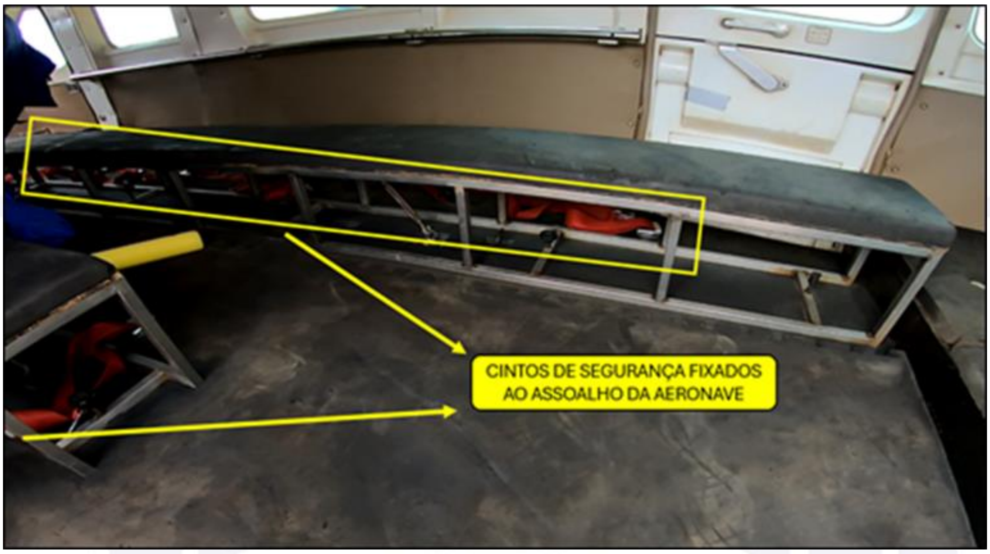

Figure 9 – Highlight showing the positioning of the seat belts attached to the floor on only one side of the benches (outer sides of the cargo cabin).

Regarding the updating of the aircraft's internal configuration, on March 10, 2022, an amendment was issued to Supplemental Type Certificate (CST) nº 2021S09-06, published by ANAC, to include the PT-OQR aircraft in the list of aircraft authorized to undergo the modifications outlined in the Master List of Technical Documents nº JA-408-1000, Rev. 7, dated January 24, 2022, issued by *Jazz Engenharia Aeronáutica Ltda.* (COM nº 2003-32/ANAC).

On March 15, 2022, the Supplement nº H.02-5037-0/ANAC/2021 was reissued by ANAC, containing the necessary information for operations involving the installation of benches for accommodating parachutists, thereby including the PT-OQR airplane in this documentation.

This update referred to the installation of a roll-up door, benches aimed at parachutist seating, a power adapter, side handrails for parachutist support, an external step and handles for tandem jump support, warning lights and audible alerts for instructions to parachutists, and polyethylene foam padding on the aircraft floor and bench surfaces.

Also on March 15, 2022, a letter of authorization was issued allowing the maintenance organization *CONAL AVIONICS* (COM nº 9012-08/ANAC) to utilize the aforementioned CST, relating to the configuration change certification for parachute drop operations.

Thus, it was noted that although all documentation had been submitted to enable the aircraft PT-OQR to undergo a configuration change, there was no actual incorporation of the modification into the aircraft's official records.

No documents were presented to the Investigation Committee to confirm that the configuration change had been effectively implemented, nor was any maintenance documentation found recording the modification for parachute drop operations.

Additionally, the list of major modifications dated May 17, 2022 — prepared after the accident — did not include the installation of benches for parachutists.

In relation to the parachutists’ seat belts, there was no specific maintenance program in place due to the major modification carried out in 2011. No records were found in the aircraft’s airframe logbooks concerning maintenance specifically related to the items installed during the modification.

As for the manufacturer's guidance applicable to aircraft without the modification, it was verified that the maintenance task 25-21-00-220 — which referred to the detailed inspection of passenger seats — was included in the Inspection Document nº 10 of the maintenance manual for Cessna Aircraft model 208. This inspection was required every 800 flight hours or every 24 calendar months, whichever came first (Figure 10).

CESSNA®
MODEL 208
MAINTENANCE MANUAL

PASSENGER SEATS - INSPECTION/CHECK

1. **General**
   A. This section has the inspections and checks necessary to keep the passenger seats in a serviceable condition.

Task 25-21-00-220

2. **Passenger Seats Detailed Inspection**
   A. General
      (1) This task gives the procedures to do a detailed inspection of the passenger seats.
   B. Special Tools
      (1) None
   C. Access
      (1) None
   D. Do a Detailed Inspection of the Passenger Seats.
      (1) Examine all passenger seat assemblies for rips, tears, cleanliness, security of attached components, and other signs or damage.
      (2) Examine the seat belts, shoulder straps, restraint straps, and retainers for security of installation, rips, cuts, tears, frayed edges, cleanliness, and general condition.
         (a) Replace frayed and/or cut belts.
      (3) Examine all belts for legibility of the certification label.
      (4) Examine the belt length adjustments for correct operation.
      (5) Examine all belt attach points for security and damage.
      (6) Examine the buckle assemblies for signs of wear, cleanliness, security, and general condition.
      (7) Examine the belt latching mechanism for correct operation.
      (8) Examine the seat belt inertia reels for security and general condition.
      (9) Check the inertia reel

Figure 10 – Tasks related to the inspection of the passenger seats, as specified in Inspection Document nº 10 of the aircraft maintenance manual.

The most recent inspection related to Inspection Document nº 10 was recorded on September 16, 2021, at 9,309 flight hours and 12 minutes of total airframe time — 221 hours and 24 minutes before the accident.

Concerning the detailed inspection of the seat rails and their attachment structure, it was found that this task was included in Inspection Document nº 15 of the maintenance manual for Cessna Aircraft model 208 and was required at 7,500 flight hours and every 2,500 flight hours thereafter.

The last inspection related to Inspection Document nº. 15, concerning the verification of seat rails and attachment structures, was recorded on June 23, 2016, at 7,499 flight hours and 24 minutes of total airframe time.

With regard to the structural protection of aircraft occupants, the RBAC-23, Amendment nº 64, approved by Resolution nº 524 of August 2, 2019, section 23.2270 Emergency conditions, included the information shown in Figures 11 and 12.

STRUCTURAL OCCUPANT PROTECTION	PROTEÇÃO ESTRUTURAL DOS OCUPANTES
23.2270 Emergency conditions.	**23.2270 Condições de emergência.**
(a) The airplane, even when damaged in an emergency landing, must protect each occupant against injury that would preclude egress when:	(a) O avião, mesmo quando danificado em um pouso de emergência, deve proteger cada ocupante contra lesões que impediriam a evacuação quando:
(1) Properly using safety equipment and features provided for in the design;	(1) Usar corretamente o equipamento de segurança e os recursos previstos no projeto;
(2) The occupant experiences ultimate static inertia loads likely to occur in an emergency landing; and	(2) O ocupante experimentar as cargas estáticas finais de inércia prováveis de ocorrerem em um pouso de emergência; e
(3) Items of mass, including engines or auxiliary power units (APUs), within or aft of the cabin, that could injure an occupant, experience ultimate static inertia loads likely to occur in an emergency landing.	(3) Itens de massa, incluindo motores ou unidades de potência auxiliar (APUs), dentro ou atrás da cabine, que possam ferir um ocupante, quando experimentando as cargas finais de inércia prováveis de ocorrerem em um pouso de emergência.

Figure 11 - RBAC 23, EMD nº 64, section 23.2270.

(b) The emergency landing conditions specified in paragraph (a)(1) and (a)(2) of this section, must:	(b) As condições de pouso de emergência especificadas no parágrafo (a)(1) e (a)(2) desta seção, devem:
(1) Include dynamic conditions that are likely to occur in an emergency landing; and	(1) Incluir condições dinâmicas que são prováveis de ocorrer em um pouso de emergência; e
(2) Not generate loads experienced by the occupants, which exceed established human injury criteria for human tolerance due to restraint or contact with objects in the airplane.	(2) Não gerar cargas experimentadas pelos ocupantes, que excedam aos critérios de ferimentos que um ser humano suporta, devido às contenções ou contato com objetos no avião.
(c) The airplane must provide protection for all occupants, accounting for likely flight, ground, and emergency landing conditions.	(c) O avião deve prover proteção para todos ocupantes, levando em conta ascondições prováveis de voo, solo e pouso de emergência.
(d) Each occupant protection system must perform its intended function and not create a hazard that could cause a secondary injury to an occupant. The occupant protection system must not prevent occupant egress or interfere with the operation of the airplane when not in use.	(d) Cada sistema de proteção do ocupante deve exercer sua função pretendida e não criar um perigo que poderia causar um ferimento secundário em um ocupante. O sistema de proteção do ocupante não deve impedir a saída do ocupante ou interferir com a operação do avião quando não estiver em uso.

Figure 12 - RBAC 23, EMD nº 64, section 23.2270 (continuation).

1.7. Meteorological information.

The Meteorological Aerodrome Reports (METAR) from *Sorocaba* Aerodrome (SDCO), State of *São Paulo*, located 15 NM from the accident site, provided the following information:

METAR SDCO 111400Z 36005KT 330V040 9999 FEW020 BKN080 22/17 Q1017=

METAR SDCO 111500Z 34010KT 310V010 9999 FEW030 BKN080 23/16 Q1016=

METAR SDCO 111600Z 34010KT 9999 FEW030 BKN080 23/17 Q1015=

At 1500 UTC, there were few clouds at 3,000 ft., a ceiling at 8,000 ft., wind varying between 310° and 010°, and visibility greater than 10 km at SDCO.

Denser cloud formations were observed on radar to the east and south of *Boituva*, State of *São Paulo*, as shown in the *Maxxcappi* radar image from May 11, 2022, at 1507 UTC (Figure 13).

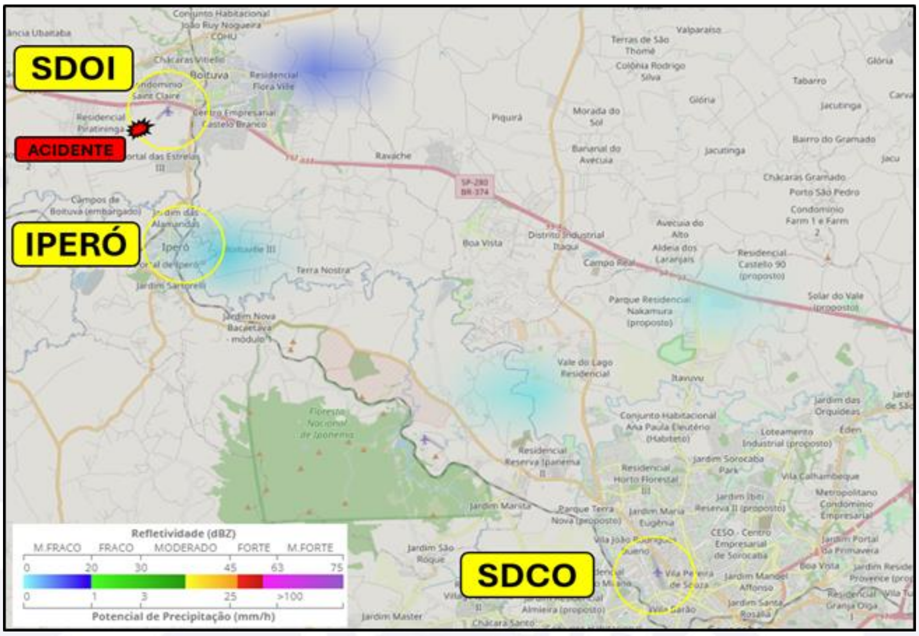

Figure 13 – *Maxxcappi* radar image from May 11, 2022, at 1507 UTC.
Source: adapted from https://www.redemet.aer.mil.br/.

Figure 14 displays data from the automatic rain gauge station [A713] in the city of *Iperó*, State of *São Paulo*, located 3 NM from the accident site.

Data	Hora	Temperatura (°C)			Umidade (%)			Pto. Orvalho (°C)			Pressão (hPa)			Vento			Radiação	Chuva
11/05/2022	UTC	Inst.	Máx.	Mín.	Inst.	Máx.	Mín.	Inst.	Máx.	Mín.	Inst.	Máx.	Mín.	Vel. (m/s)	Dir. (°)	Raj. (m/s)	Kj/m²	mm
	1500	23,3	23,4	22	65	71	65	16,4	17,4	16	945,6	946,5	945,6	2,6	297	5,5	1	0

Figure 14 – Data from station [A713] *IPERÓ*, SP, on May 11, 2022, at 1500 UTC.
Source: adapted from https://mapas.inmet.gov.br.

In addition, in the images captured shortly after the accident, horizontal visibility was consistent with the METARs issued for *Sorocaba* Aerodrome at 1400 UTC, 1500 UTC, and 1600 UTC, as well as the presence of vertical cloud formation and surrounding clouds at the accident site, indicating a ceiling above the minimums, as seen in Figures 15 and 16.

Figure 15 – Presence of clouds at the accident site shortly after the occurrence.

Figure 16 – Horizontal visibility at the site, shortly after the accident.

Accordingly, it was concluded that the meteorological conditions were above the minimums required for the operation under visual flight rules (VFR).

1.8. Aids to navigation.

NIL.

1.9. Communications.

NIL.

1.10. Aerodrome information.

Not applicable.

1.11. Flight recorders.

Not required and not installed.

1.12. Wreckage and impact information.

The impact occurred off-aerodrome in a rural area, approximately 0.9 NM from runway threshold 24 of SDOI, on a slope parallel to a dirt road. Evidence showed four impact marks from the landing gear on the ground prior to the final collision. The wreckage distribution was classified as concentrated.

The first tire contact with the ground during the emergency landing occurred in a nose-high attitude, with forward momentum, on uphill terrain. The final impact occurred against a slope, at an angle of approximately 80° relative to the direction of the dirt road, as shown in Figures 17 and 18.

Figure 17 – Final trajectory of the aircraft.

Figure 18 – View from the helmet camera of one of the parachutists, highlighting the slope struck in the final collision.

The nose landing gear separated at the final impact, and the left main landing gear struck the slope before the right main gear, generating a yawing moment to the left and causing the aircraft to overturn.

The engine mount detached from the aircraft, and the entire assembly rotated 90° relative to its longitudinal axis.

The fuselage was slightly wrinkled due to the angle at which the aircraft struck the slope and the final yawing movement after impact.

The vertical stabilizer was destroyed due to ground impact.

The flaps were found in the extended position. The rudder trim was set to the right (nose right), the aileron trim to the right (roll right), and the elevator trim was set nose down.

Figure 19 – Final resting position of the aircraft.

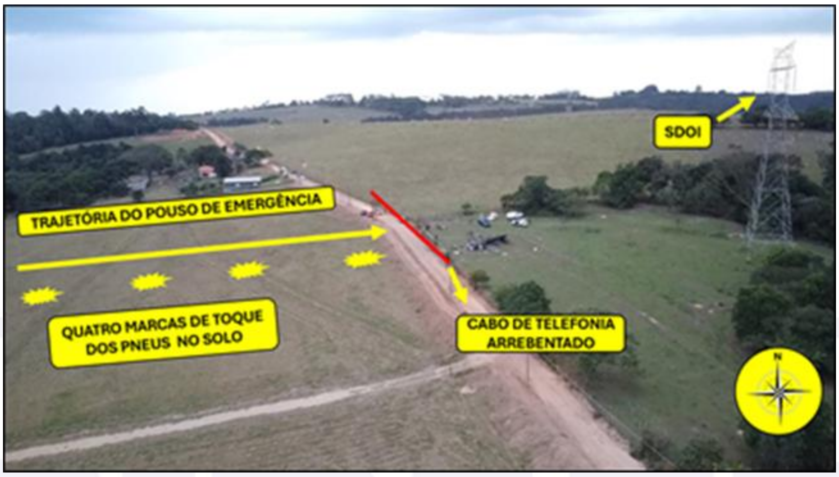

Figure 20 – Sketch of the accident.

The terrain where the emergency landing took place had an approximate length of 200 meters, was uphill, and had an irregular surface, as shown in Figure 21.

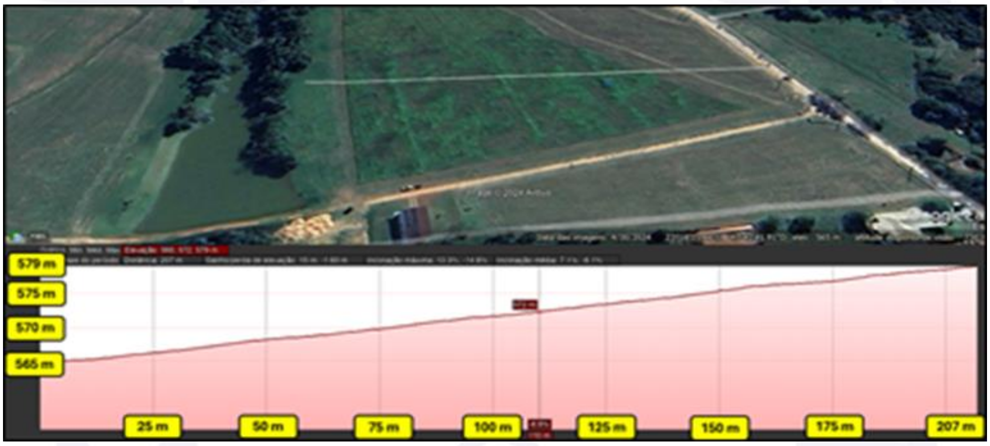

Figure 21 – Elevation profile view of the emergency landing site.
Source: adapted from Google Earth.

From the footage obtained from one of the parachutists' helmet camera, it was determined that the aircraft traveled approximately 200 meters in about 7 seconds.

Thus, the estimated average speed of the aircraft during the emergency landing was 55 kt., or approximately 102 km/h.

After passing over a line of trees, the aircraft flew approximately 85 meters over the landing terrain, leaving 115 meters for deceleration after initial touchdown, as shown in Figure 22.

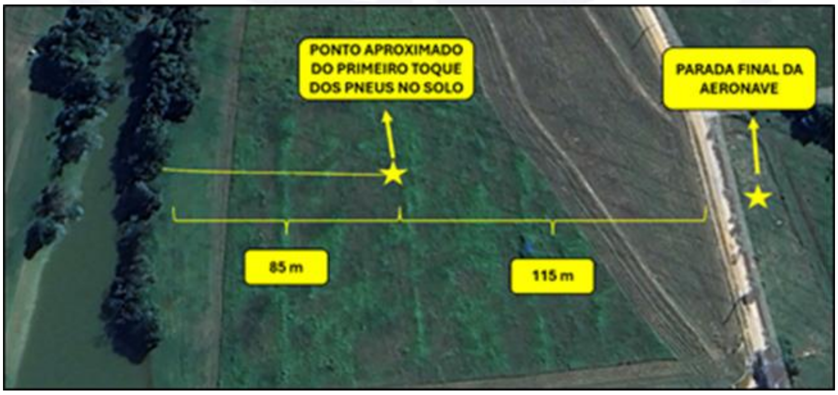

Figure 22 – Approximate distances traveled by the aircraft during landing.
Source: adapted from Google Earth.

After the first tire contact with the ground, the aircraft floated and made three additional contacts on irregular terrain with several contour changes, heading toward the higher ground.

Regarding the parachutists' positioning at the time of impact, it was observed that the first parachutist seated on the left bench of the aircraft (closest to the pilot) had his back away from the seat backrest, as shown in Figure 23.

Figure 23 – First parachutist on the left bench of the aircraft (closest to the pilot) with back away from the seat backrest, pre-impact (left) and post-impact (right).

The first parachutist on the right bench of the aircraft (to the pilot’s right) also had his back away from the parachutist bench backrest and was sideways relative to the direction of aircraft movement at the moment of impact, as shown in Figure 24.

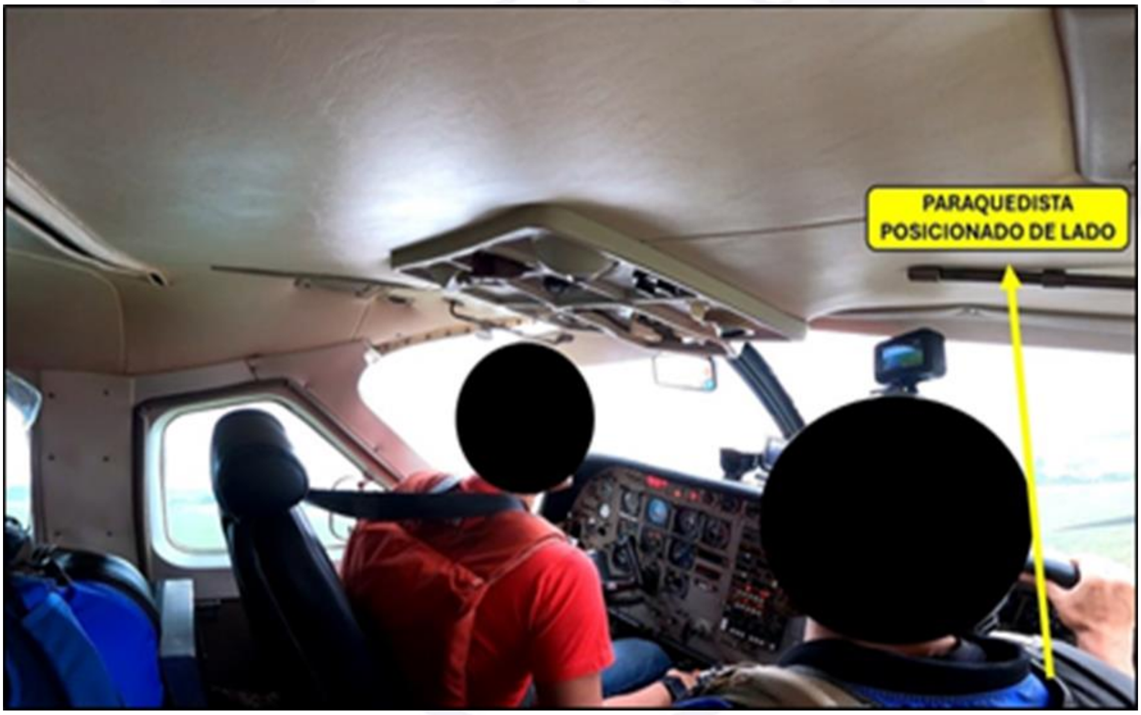

Figure 24 – First parachutist on the right bench (pilot’s right side) seated sideways with his back away from the seat backrest.

1.13. Medical and pathological information.

1.13.1. Medical aspects.

NIL.

1.13.2. Ergonomic information.

NIL.

1.13.3. Psychological aspects.

NIL.

1.14. Fire.

Footage from one of the parachutists' cameras showed flames emerging from the engine exhaust moments before the emergency landing, as illustrated in Figure 25.

Figure 25 – Flames visible from the left exhaust moments before the emergency landing.

1.15. Survival aspects.

Following the impact, the aircraft occupants were thrown forward, compressing the pilot's seat and those located toward the front of the cabin. Most of the passenger seat belts were torn due to the impact, as illustrated in Figures 26 through 30.

Figure 26 – Seat belts found at the front of the aircraft: missing anchor ring (highlighted on the left) and with intact anchor rings (highlighted on the right).

Figure 27 – Seat belt found next to the aircraft, with intact anchor ring.

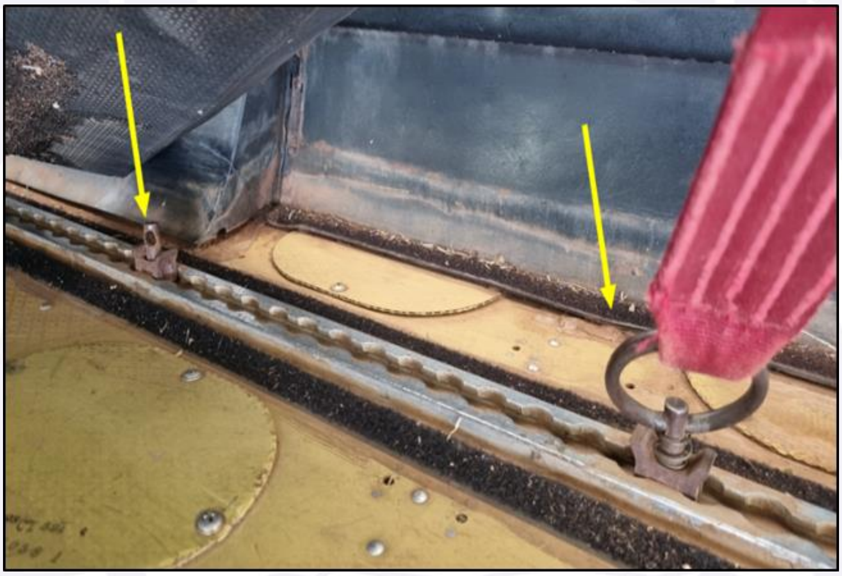

Figure 28 – Belt attachment fittings on the aircraft floor rails showing signs of corrosion (highlighted in yellow).

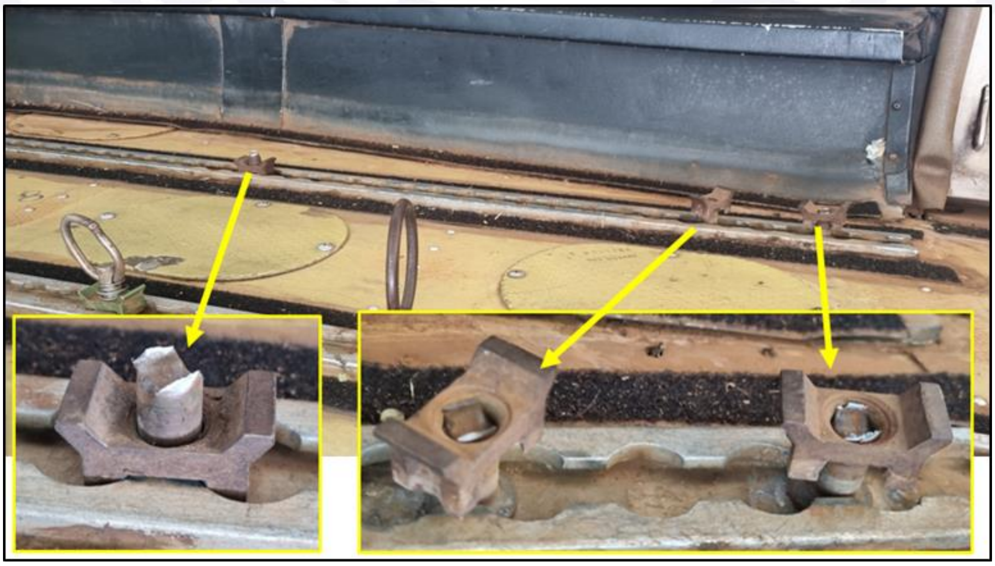

Figure 29 – Sheared belt attachment fittings on the aircraft floor rails (highlighted in yellow).

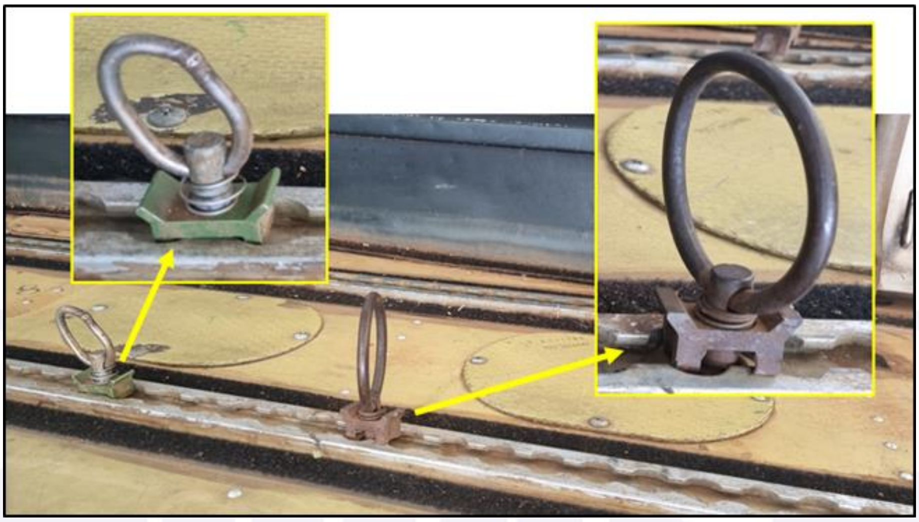

Figure 30 – Belt attachment fittings on the aircraft floor rails found in the unlocked position (highlighted in yellow).

Some of the attachment fittings were sheared, and some of the anchor rings were broken. In addition, some of the seat belts were torn. Rust marks were also observed on the sheared fittings, as shown in Figures 27 to 30.

Video footage recorded by one of the parachutists' cameras showed that the first parachutist seated on the right side of the aircraft was thrown out of the aircraft after impact with the slope, and a second parachutist ended up partially outside the aircraft. The pilot and passengers were rescued by the *São Paulo* State Military Police and Fire Department.

1.16. Tests and research.

Analyses were carried out to verify the conformity of the engine lubricating oil and fuel samples with the required specifications and/or the presence of contaminants that could have contributed to the occurrence. The results obtained from the fuel and engine oil samples were in accordance with their respective specifications and showed no signs of contamination.

During the investigation, an analysis was conducted on the Pratt & Whitney engine, model PT6A-42A, SN PCE - RM0557. It was observed that, externally, the engine did not suffer significant damage. However, the FCU sustained damage that prevented it from being tested on a test bench. Impact marks were observed on the left exhaust duct, from the inside out, as shown in Figures 31 and 32.

Figure 31 – Damage observed on the aircraft's left exhaust duct.

Figure 32 – Damage observed on the aircraft's left exhaust duct.

The torque and safety wiring of the engine pneumatic line connections were verified, and it was found that they were properly torqued and safety-wired, as shown in Figures 33 and 34. In addition, the PY and P3 lines were tested, and no leaks were found along their lengths.

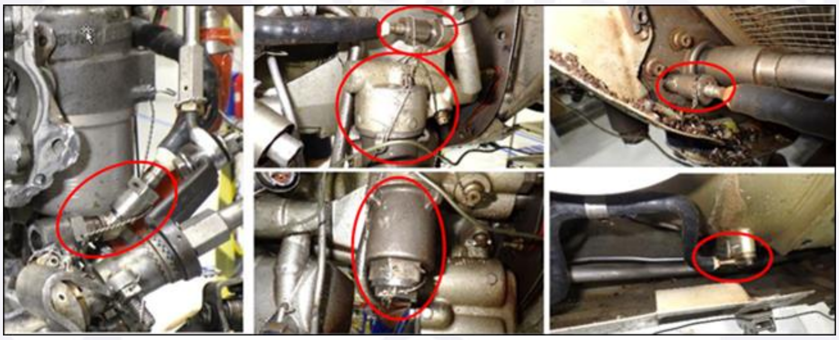

Figure 33 – P3 line properly installed and safety-wired.

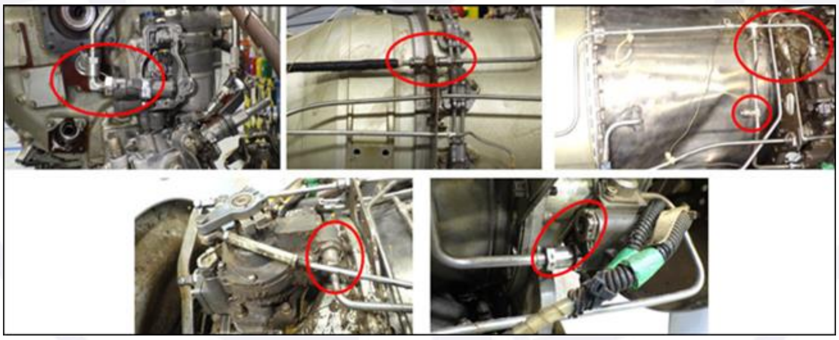

Figure 34 – PY line properly installed and safety-wired.

The engine bleed valves underwent functional bench testing and no leaks were found; however, it was verified that the control pressure limits were below those specified in the manual, as shown in Table 1.

Part Number	Min. (PSIA)	Max. (PSIA)	Measured (PSIA)
Low Pressure (PN: 3123123-01; SN: 9K266)	33.55	34.55	32.8
High Pressure (PN: 3123122-01; SN: 9F851)	28.30	29.20	28.0

Table 1 – Values obtained from bleed valve tests.

The main oil filter, the chip detectors from the accessory gearbox and the reduction gearbox were examined, and no signs of metallic chips were found.

No contamination that could indicate a malfunction in the engine lubrication system was found in the strainer of the main oil pump. Additionally, the engine oil sump was observed to be clean and free of contaminants.

The values obtained from the electrical resistance tests of the engine temperature compensator were within the limits established by the manufacturer.

Although the FCU was not tested on a bench due to a rupture in the governor section, it was observed that no anomalies or discrepancies were found in its internal components that could compromise its lubrication or the delivery of fuel to the engine.

Bearings 01 and 02 of the engine were inspected and did not show abnormalities that could lead to malfunction such as rubbing or seizure of the compressor, either in the hot section or in the accessory gearbox.

In the axial compressor, minor damage was observed on the first-stage blades caused by Foreign Objects (FO), along with erosion on their respective leading edges (Figure 35).

Figure 35 – First stage of the axial compressor; red arrows point to FO-induced damage.

As for the second and third stages, as well as the centrifugal stage, these components were found to be in normal condition.

Subsequently, during the analysis, it was verified that the compressor turbine blades exhibited heat damage, with approximately half of their length burned/melted. Delamination of the protective coating on the blades was also observed (Figure 36).

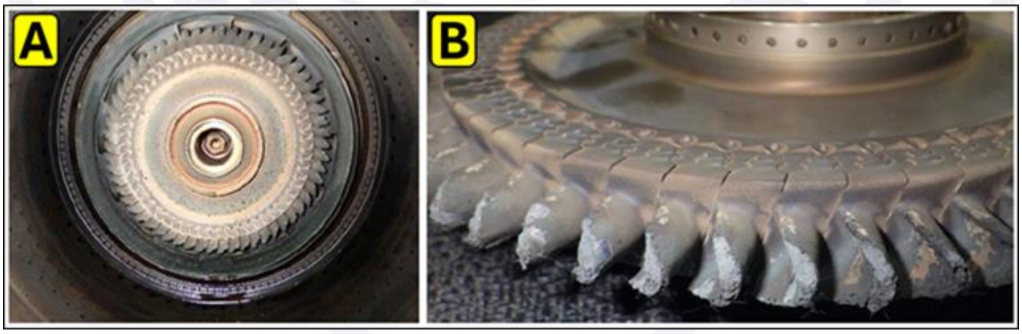

Figure 36 – (A) – Heat damage on the compressor turbine blades.
(B) – Delamination of the protective coating on the blades.

A large amount of soot was observed deposited inside the combustion chamber and on the fuel nozzles, indicating that the engine operated with a rich air/fuel mixture—meaning there was more fuel than necessary for the proper combustion of the air supplied by the compressor (Figure 37).

Figure 37 – Internal and external lining of the combustion chamber showing soot deposits and carbon buildup on the walls and cooling ring.

Regarding the conditions found in the engine, it was possible to observe that its temperature, during operation, reached high levels, exceeding the material resistance limit of the turbine blades. This caused a change in the physical state of the material (melting), leading to its deterioration, with part of the melted material being deposited on the shroud due to centrifugal force.

The remaining portion of this material was carried by the flow of overheated gases, and the impact of these particles on the stages of the power turbine caused damage to the stator vanes and blades. As a result, fragments from these blades collided with the exhaust ducts, leaving visible marks on the left duct.

The entire stator of the first stage of the power turbine was melted, and its inner rim was fractured, as shown in Figure 38(A). Only a small portion of the vanes was observed on the inner and outer edges (red arrows). The T5 probes (Figure 38 B) were melted/fractured (blue arrows).

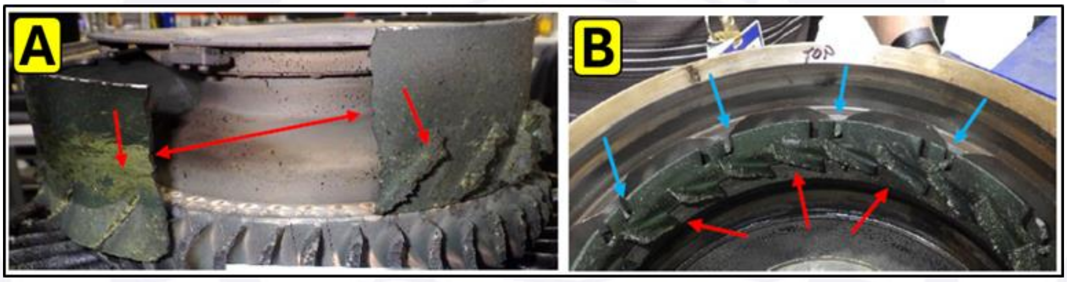

Figure 38 – Close-up: stators indicated with red arrows and T5 probes with blue arrows.

The blades of the first stage of the power turbine were fractured approximately 0.63 cm from their roots, as shown in Figure 39(A). In addition, signs of rubbing were observed on the remaining portion of the leading edge of the blades, extending from the root to the fractured area (Figure 39 B). The fracture surface of the blades displayed an irregular pattern, characteristic of overload, as shown in Figure 40.

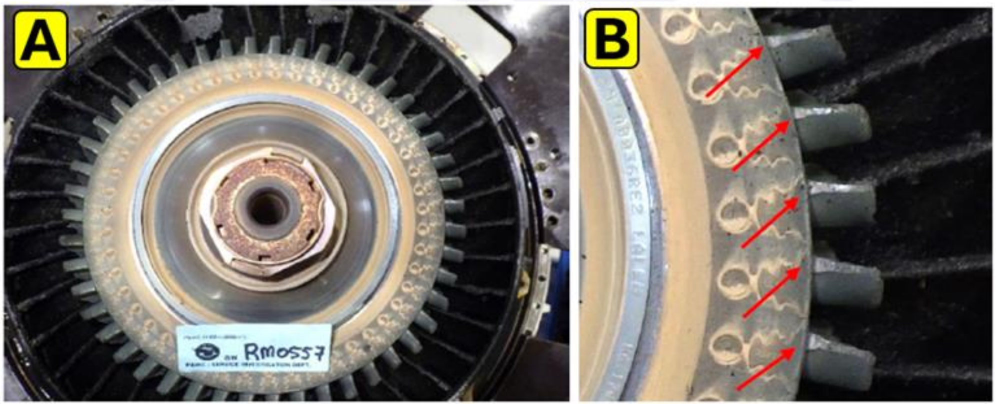

Figure 39 – (A) First stage of the power turbine with fractured blades; detail of rubbing on the blades indicated with red arrows (B).

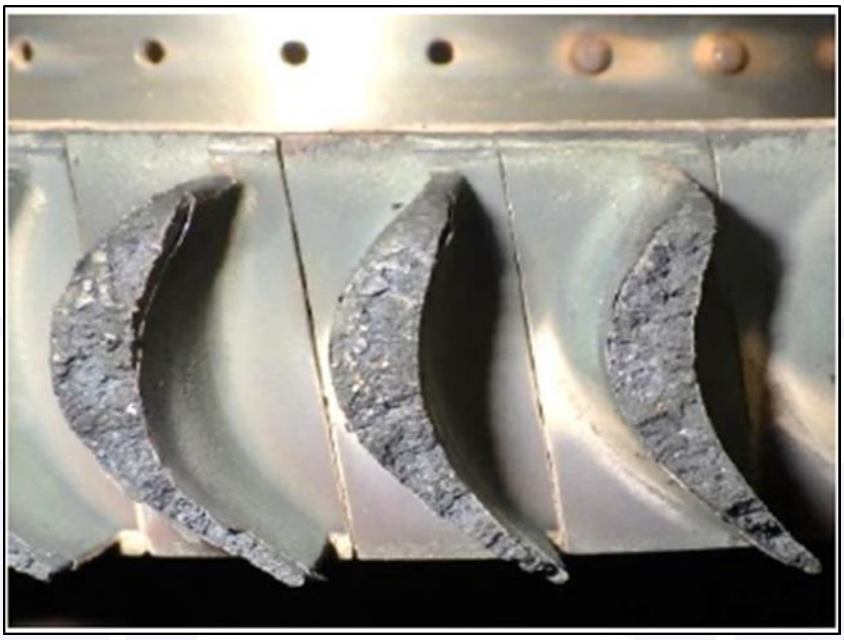

Figure 40 – Frontal view of the blades from the first stage of the power turbine.

Figure 41 shows the stators of the second stage of the power turbine with impact damage and splashes of material on the airfoil surfaces. Additionally, debris from the ring and blades of the first stage of the power turbine was found lodged between the airfoils.

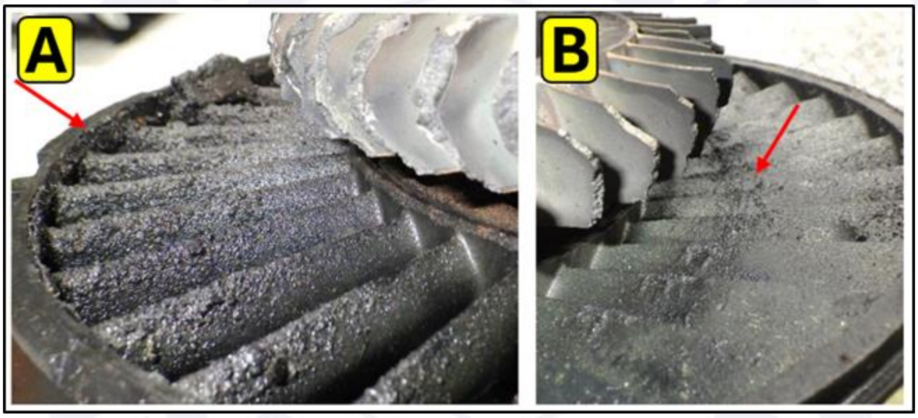

Figure 41 – Leading edge of the second-stage power turbine stator (A) and trailing edge on the right (B).

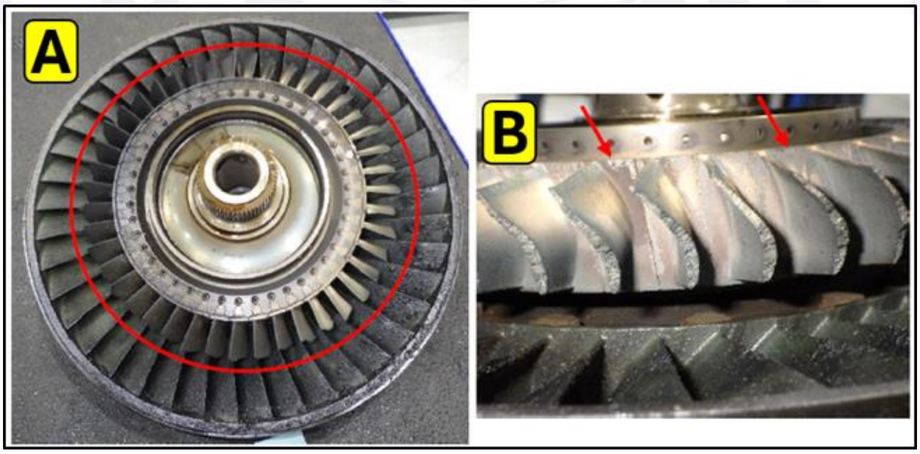

Figure 42 – Second stage of the power turbine (A) and presence of corrosion highlighted with red arrows (B).

In the reduction gearbox, the second-stage sun gear and the first-stage planetary gears were found undamaged.

The propeller blades showed signs that the engine was not producing power at the moment the aircraft performed the emergency landing.

1.17. Organizational and management information.

The company that owned the aircraft operated in accordance with the requirements established in the RBAC-91 – "General Operating and Flight Rules" and RBAC-105 – "Parachute Operations," with operational specifications under Specialized Air Services (SAE) for parachute drop missions.

The operator's base was located at SDOI Aerodrome, in *Boituva*, *São Paulo*.

On the date of the accident, the corresponding Air Operator Certificate (COA) was valid.

According to its Operational Specification (EO), the company was authorized to operate two aircraft models, namely the 208 and 208B, both manufactured by Cessna Aircraft.

At the time of the accident, the organization had a Safety Management Manual (SMM) that was duly accepted by ANAC.

With regard to the company's Operations Manual, it was verified that, for pre-solo flights, emergency training in the traffic pattern was prescribed. However, the manual did not contain specific instructions on how such training should be conducted.

It was noted that pilots were expected to complete a theoretical exam annually, which included topics on aircraft emergencies. In addition, a flight accompanied by another pilot was scheduled every six months with the purpose of updating flight skills and correcting personal habits that could have been developed. However, the completion of emergency training was not mandatory.

During the data collection phase of the investigation, it was found that, upon beginning their flights with the company, pilots underwent training aimed at adapting the use of the Emergency Power Lever (EPL) in flight. Regarding this training, it was verified that not all pilots confirmed having received this in-flight instruction, since some were already experienced in operating this type of aircraft prior to joining the company.

In this context, pilots who had previously received such training reported that the exercise was performed with the propeller unfeathered and the power set to 300 lb., in order to simulate a glide ratio similar to that of an engine-out situation with the propeller feathered. From the traffic pattern, the EPL was used to assess the sensitivity of that control.

Additionally, it was also reported that, after the initial EPL usage training, it was up to each pilot to conduct their own emergency training.

With regard to the use of the EPL, the following standard procedure was observed in the operator's Operations Manual for actual emergencies:

> ENGINE FAILURE AFTER TAKEOFF:
>
> - The responsibility for decision-making in the event of an emergency rests with the pilot, who must follow the guidance provided in the Aircraft Operator's Manual (POH). In case of doubt about the most suitable locations for an emergency landing, the pilot should consider the safest available options.
>
> - The Emergency Power Lever must be used with caution, always prioritizing operational safety.

Some pilots also reported that, during the prescribed *before starting engine* checks, they informally checked whether the EPL lever moved freely. This practice occasionally resulted in the breakage of the safety wire that ensured the lever's proper functionality. Although it was customary for pilots to perform this EPL lever check, such a procedure was not included in the *before starting engine* checklist, section 4, Normal Procedures, of the aircraft manual.

That specific checklist only required the EPL to be in the full aft position and the EMERG PWR LVR message to be off on the aircraft's warning panel.

During the investigation, reports were collected indicating that the aircraft had experienced issues with the FCU between 2014 and 2015, as well as multiple occurrences of compressor stalls throughout those years—particularly during the second pass for parachute drops, when engine power was reduced.

After undergoing some maintenance procedures, pilots reported that the aircraft began to present compressor stall issues again in 2020. By mid-September 2021, the aircraft was exhibiting such problems during most flights, already on the first pass for parachute drops.

Following this period, during which compressor stall issues were reported, the aircraft was sent for engine adjustment maintenance, as noted in section 1.6 of this report, and it resumed operation in December 2021.

1.18. Operational information.

The accident flight was the fourth parachute drop flight of the day.

The aircraft's basic operating weight was 2,022 kg, and it was refueled with 400 liters of fuel prior to the flight. Adding the weight of the crewmember and 15 passengers, the estimated takeoff weight was 3,616 kg, with the Center of Gravity (CG) at 4.532 m. The aircraft's Maximum Takeoff Weight (MTOW) was 3,629 kg.

Thus, it was concluded that the aircraft was operating within the weight and balance limits.

After engine start, 15 parachutists boarded the aircraft. A recording made by one of them showed that takeoff occurred without issues up to the point of rotation, when the parachutist turned off the camera.

According to the pilot's statement, at an altitude of approximately 1,000 to 1,100 feet, the aircraft experienced a sudden power loss, and banging sounds were heard.

Since the emergency occurred at that altitude, none of the parachutists exited the aircraft, in accordance with the emergency procedures in effect at the time.

Footage from a helmet-mounted camera worn by one of the parachutists showed that the Interstage Turbine Temperature (ITT) indication was near the upper limit of the instrument's range, as shown in Figure 43.

Figure 43 – ITT indication near the instrument's upper limit.

Figure 44 – Photo of the ITT indicator taken after the accident.

Figure 45 shows the ITT operating limits as displayed on the indicator. Continuous engine operation was limited to 770°C; takeoff was limited to 800°C, for a maximum of 5 seconds after exceeding 770°C; and the maximum transient limit during start-up was 1,000°C, for a maximum of 5 seconds after exceeding 850°C.

INSTRUMENT	RED RADIAL MINIMUM	YELLOW ARC CAUTION	GREEN ARC NORMAL OPERATING	RED RADIAL MAXIMUM	RED DASHED RADIAL MAXIMUM
Inter-Turbine Temperature Indicator (ITT)		770-800	400 to 770	800	1000

Figure 45 – ITT operating limits.

With regard to the procedures specified in the aircraft's operating manual, the following aspects should be highlighted:

For the in-flight emergency "Engine Failure in Flight," the checklist included the following sequence:

- Airspeed – 95 kt.
- Power Lever – IDLE
- Propeller Lever – FEATHER
- Fuel Lever – CUTOFF
- Flaps – RETRACT
- Fuel Pump – OFF
- Fuel Shutoff Valve – PULL
- Ignition – NORMAL
- Alternator – OFF
- Electrical Load – REDUCE

According to the manufacturer, an engine failure in flight could be identified by abnormal temperatures, "metallic" noises, or high vibration levels, in conjunction with a loss of power. An engine flameout would be indicated by a drop in ITT, torque, and Ng.

According to the pilot, during the accident flight, when the engine began to fail, power dropped to around 800 lb. of torque, and engine shutdown was not performed.

The aircraft manual included a cautionary note advising that no attempt should be made to restart the engine in flight unless the failure had been positively identified.

According to data collected, the pilot, in an attempt to restore engine power, activated the EPL. It is noteworthy that this lever allowed for direct fuel flow bypassing the FCU in case of FCU failure.

According to the aircraft manual, a failure in the FCU could cause the fuel flow to drop to the minimum corresponding to IDLE. Other symptoms of this type of failure included ITT indications within the typical lower in-flight range (from 500°C to 600°C), Ng at 48% or higher, and lack of engine response to movements of the power lever.

For the "FCU Failure" emergency, the following sequence was specified in the checklist:

- Power Lever – MINIMUM
- Emergency Power Lever – Select power as needed (maintain at least 65% Ng)

Use of the EPL was restricted to FCU failure cases, as, according to the aircraft manual, the engine response would be quicker than when using the power lever. However, additional caution was required during acceleration to avoid exceeding engine limits.

1.19. Additional information.

Regarding the phenomenon of compressor stall, as defined in the glossary of the Airplane Flying Handbook (FAA-H-8083-3A), it is a condition in which, in an axial compressor, the airflow fails to pass to subsequent stages, caused by a pressure ratio incompatible with the engine's rotational speed.

This phenomenon can result from several conditions, such as: damage to the compressor blades caused by FOD, erosion from sand or dirt on the compressor blades, accumulated dirt within the compressor, wear, or excessive or insufficient fuel flow caused by abrupt movements of the power lever, among others.

The result of this phenomenon may include a temporary loss of power, loud bangs, an increase in exhaust temperature, visible flames from the exhaust, fluctuations in engine RPM, flameout, and other symptoms.

According to the aircraft's emergency procedures described in Section 4, item Engine Compressor Stalls, a compressor stall condition could be resolved by reducing engine power to a setting at which the banging stops, and then slowly advancing the power lever to the desired power setting.

Regarding sport parachuting activity, the Federal Aviation Administration (FAA) of the United States issued Advisory Circular nº 105-2E, in effect since December 4, 2013, with the purpose of providing recommendations to improve safety and to disseminate information to assist all involved parties.

This circular addressed, in its Appendix 3, seats and restraint systems, and presented information on quick-release track fittings, stating that single-pin types would detach from the track under dynamic loads lower than their nominal load rating. The document also clarified that quick-release fittings with double pins did not exhibit this behavior during dynamic testing. Therefore, double-pin quick-release track fittings, such as the one shown in Figure 46, would provide more reliable anchorage than single-pin fittings.

Figure 46 – Double-pin quick-release track fitting.
Source: FAA Advisory Circular nº 105-2E.

The aforementioned Advisory Circular also described best practices for restraint, aiming to increase the effectiveness of occupant retention in the event of an emergency landing.

In this regard, the circular included information on the number of attachment points for parachutists' seatbelts, indicating that double-belt attachment provided superior restraint compared to single-side attachment on parachutists.

In addition to this circular, the FAA published, in March 1998, document DOT/FAA/AM-98/11, which consisted of an evaluation of different types of parachutist restraint using seatbelts, seeking the safest solution for an emergency landing scenario.

In the impact tests performed, it was observed that when belts were attached on both sides of the parachutist, the body tended not to rotate laterally, remained upright, and exhibited less longitudinal displacement.

Conversely, in the tests conducted with the belt attached on only one side of the parachutist, the test dummy slid significantly to the side, as well as forward (in relation to the aircraft), experiencing higher post-impact reaction forces.

Finally, Supplement nº H.02-5037-0/ANAC/2021, dated May 15, 2022, governed the modification of the aircraft configuration for parachute drop operations. It required the installation of 30 seatbelts, with two belts per parachutist (one on each side), and included continued airworthiness instructions aimed at the maintenance of the items related to the modification.

If the configuration changes were implemented, Continued Airworthiness Instructions JA-408-1220 would apply, based on ANAC Process nº H.02-5037-0. However, this supplement had not yet been incorporated into aircraft PT-OQR before the accident.

1.20. Useful or effective investigation techniques.

NIL.

2. ANALYSIS.

This was a local flight for parachute drop operations, departing from SDOI, *Boituva*, *São Paulo*, with one pilot and fifteen parachutists on board.

The pilot was qualified and had experience with this type of operation.

The weather conditions were above the minimums required for conducting the operation under visual flight rules, and the aircraft was operating within its weight and balance limits.

Regarding the maintenance history of the aircraft’s engine, it was observed that over nine years of operation, the engine underwent several corrective maintenance procedures related to the fuel system and the hot section. At 940 flight hours, the engine presented issues with the FCU, which was replaced twice between 2014 and 2015. Furthermore, in 2015, a more extensive unscheduled maintenance was carried out to investigate issues in the aircraft’s fuel system.

In 2017, a borescope inspection of the engine revealed the following discrepancies: burning, erosion, and material loss in the cooling rings, with values exceeding the allowable limits on the outer liner of the combustion chamber, as well as erosion, material loss, and cracking beyond acceptable limits in the small duct. That year, the compressor stator assembly was replaced; however, there is no record of replacement of the outer liner of the combustion chamber.

In 2019, 947 flight hours after the borescope inspection performed in 2017, cracks were found in the inner liner and, again, in the outer liner of the combustion chamber, and both components were replaced.

In 2020, repairs were performed on the compressor stator, and in 2021, cracks were once again found in the engine’s combustion chamber, along with burn marks, erosion, and material loss on some stator vanes.

In 2021, the aircraft underwent maintenance to investigate a malfunction related to compressor stall. General repairs and adjustments were made to the engine, including replacement of compressor turbine stator vanes, the inner liner and outer liner of the combustion chamber, the spacer oil slinger, 36 blades of the second-stage compressor, 36 blades of the third-stage compressor, and both bleed valves.

In 2022, another replacement of the engine's FCU was carried out, along with a test bench run, and the replacement of the Gearshaft Drive from the Accessory Gearbox and the Wiring Harness.

In this context, considering the repeated maintenance interventions involving the engine's hot section, as well as the successive replacements of components from that section, it was inferred that the aircraft might have been operating continuously above normal operational limits.

With regard to the operational practices of some of the company's pilots concerning the use of the EPL and the training for landings involving its use, it was observed that the aircraft manual prohibited the use of this lever when the primary power lever was not in the IDLE position.

According to data collected, during emergency landing training sessions that required the use of the EPL, some pilots applied 300 lb. of torque in flight to simulate a feathered propeller. However, it was not possible to ensure that this setting of the primary lever corresponded to the IDLE position.

Further concerning the emergency landing training conducted by the pilots, although there was no company-issued documentation specifying how the exercise should be performed, it was observed that the practices related to the use of the EPL were not in accordance with the manufacturer's manual. The investigation found that the manufacturer’s manual stated that this lever should be used only in the event of an FCU malfunction.

Furthermore, the verification of free movement of the EPL during the before-start check was not included in the aircraft’s normal procedures. However, it was observed that this action was commonly performed by the pilots.

In addition, the use of the EPL in flight contradicted the manufacturer’s guidelines, as it was routinely employed for certain types of training. According to the manufacturer’s manual, improper use of the EPL could adversely affect its performance as well as its durability. However, it was not possible to determine the specific consequences and impacts that may have occurred in the engine components due to this operation outside the manufacturer’s parameters.

Given that the engine underwent several corrective maintenance actions related to the fuel system and the hot section over nine years of use and 3,526 total flight hours, it is possible that the use of the emergency lever in disagreement with the manufacturer’s guidelines contributed to the recurrence of malfunctions involving the engine and its components.

Regarding the functional test of this lever, as specified by the manufacturer and carried out by the maintenance team, it was verified that the procedure had been performed every 200 flight hours by qualified personnel since the engine’s installation.

According to a statement from PIC, at an altitude of approximately 1,000 to 1,100 feet, the aircraft experienced a sudden power loss accompanied by banging sounds from the engine. As a result, examinations, tests, and research were carried out to verify whether any engine component had malfunctioned.

The results obtained from the fuel and engine oil samples were in accordance with their respective specifications and showed no signs of contamination.

During the engine analysis, impact marks from internal components were observed on the left exhaust duct, from the inside out, indicating that internal engine deterioration had occurred.

Torque and safety-wire checks were performed on the engine’s pneumatic line connections, along with tests on the PY and P3 lines, inspections of the main oil filter and chip detectors, electrical resistance testing of the engine temperature compensator, bearing checks, among other analyses — all of which showed normal operating conditions for the components tested.

As for the bleed valve checks, it was observed that the control pressure limits were below those specified in the manual. This variation could lead to premature closing of the bleed valves, which might result in a compressor stall. However, since the variation between the bench test results and the manufacturer's specifications was small, it is possible that this condition did not influence engine operation. Additionally, no other evidence of premature bleed valve closure was found.

It is worth noting that the variation in pressure limit readings may have resulted from engine overtemperature, which caused damage to the diaphragm and sealing ring of the valves.

Nonetheless, compressor stall could still have occurred due to other factors such as engine deterioration, FOD ingestion, or other conditions, more commonly under high power settings, such as during takeoff.

As observed on the first-stage compressor blades, there was minor damage caused by FO. In addition, the recurrent maintenance performed on the aircraft's engine, along with the repeated instances of compressor stalls during parachute drop flights, indicated a condition of deterioration of this component.

During the investigation, repeated instances of compressor stall were noted in the PT-OQR aircraft in the years 2014, 2015, 2020, and 2021, even after the airplane had undergone various corrective and preventive maintenance procedures. It was not possible to determine the cause of this condition.

Although it is not possible to affirm that a compressor stall occurred during the accident flight, this possibility was not ruled out, given the presence of characteristics typically associated with this phenomenon, such as power loss, banging sounds, visible flames from the exhaust, and high ITT.

With regard to the visual inspection of the FCU's internal components, no anomalies or discrepancies were found that could compromise lubrication or fuel delivery to the engine. However, the FCU could not be bench-tested due to a rupture in its governor section. Therefore, it was not possible to verify whether a failure of the FCU had occurred.

Relatively to the pilot's actions, it is important to note that in the event of a compressor stall, the EPL should not be used, as it could further aggravate the condition.

During the investigation, it was not possible to determine the origin of the power loss reported by the pilot, and no evidence was found, during the engine analysis, of any condition that might have prevented its normal operation prior to the activation of the EPL.

Although the analyses were not able to identify the origin of the power loss, and it was not feasible to test the FCU, a malfunction of this component could not be ruled out.

Still regarding the EPL, it is worth emphasizing that, in the event of an FCU failure, the use of this lever would be indicated by the manufacturer in order to allow manual control of the fuel flow to the engine.

It is important to note that the manufacturer recommended additional caution during acceleration with this lever to avoid exceeding engine limits while manually controlling fuel flow.

Although it was not possible to determine whether the EPL was improperly used during the power loss, it must be emphasized that operating this lever without proper monitoring of parameters such as ITT could result in engine overheating.

Thus, another hypothesis for the occurrence would be an FCU failure, associated with improper use of the EPL, leading to a sudden increase in engine temperature and contributing to the damage observed on the compressor turbine blades and on the power turbine.

Additionally, during the emergency landing, flames were observed coming out of the engine’s left exhaust, indicating that the fuel supply had not been cut off, thus allowing one to rule out the hypothesis of engine flameout.

In addition to the flames, the ITT was observed to be operating near the physical limit of the indicator, denoting that the maximum temperature limit established by the manufacturer had been exceeded.

During the analysis of the components, it was found that the compressor turbine blades exhibited damage caused by heat exposure, with approximately half of their profiles burned or melted. Furthermore, a large amount of soot was observed deposited inside the combustion chamber and on the fuel nozzles, indicating that the engine had been operating with an excessively rich air/fuel mixture.

As a result, the turbine blades melted, and part of this material was deposited on the shroud due to centrifugal force. The remaining material was carried by the hot gas flow and impacted the power turbine stages, causing damage to the stator vanes and blades, which in turn fragmented and collided with the exhaust ducts, leaving visible marks.

It was observed that the blades of the first and second stages of the power turbine exhibited overload-type fractures and had soot on the fracture surfaces. These findings suggest that the fractures occurred after the onset of deterioration and overheating of the compressor turbine blades.

Although it was not possible to determine whether a compressor stall or a possible FCU failure had occurred, due to the engine degradation caused by the high temperature and the aircraft impact, it was found that there were improper procedures related to the operation of the EPL, and such operation may have accelerated the degradation of the engine and its components.

Nevertheless, it is possible that the incorrect operation of the EPL worsened the failure condition—whether it was an FCU failure or even the inappropriate use of this lever in the event of a compressor stall.

As for the landing site, the terrain was uneven, with various contour lines, in addition to an upward slope relative to the landing path. Coupled with this, the aircraft made four tire contacts with the ground, floating between those contacts.

Thus, the terrain characteristics contributed to the aircraft’s low braking efficiency, allowing it to collide with the embankment beside the road and subsequently overturn.

In relation to the parachutists’ seat belts, there was no specific maintenance program for the continued airworthiness of the items installed under the modifications found on the aircraft.

As a result, maintenance of the seat belts followed the inspection tasks applicable to the original, unmodified components, as prescribed by the aircraft manufacturer. The last inspection recorded for these items took place 221 hours and 24 minutes before the accident, approximately eight months prior to the occurrence.

Thus, the OM (Maintenance Organization) responsible for the maintenance actions performed on the aircraft as of May 2017 did not have a maintenance task schedule that reflected the actual configuration of the cabin where the aircraft's passengers—specifically, the parachutists—were seated and secured.

In this context, due to the large number of seat belts that detached as a result of shearing of the floor-mounted attachment brackets and the corroded condition of these brackets, it was found that the maintenance actions had not been effective in ensuring the integrity and reliability of the materials. These deficiencies contributed to the injuries sustained by the parachutists during the emergency landing.

Regarding the major modification applied to the aircraft, which involved the installation of parachutist seats and the removal of the copilot's seat, the Investigation Committee was not provided with pertinent documentation proving that the installation and removal of these items had been authorized.

As for the installation of the parachutists' seat belts, it was observed that these belts were installed on only one side of each parachutist, with one seat belt per individual. Each belt was attached to a single-pin quick-release bracket.

In this regard, as published by the FAA in Advisory Circular nº 105-2E, concerning sport parachuting activity, double-pin quick-release brackets had a higher nominal strength than single-pin brackets when subjected to dynamic loads. Also according to the Advisory Circular, securing seat belts to dual anchor points—i.e., one belt on each side of the parachutist—provided superior restraint compared to securing to a single anchor point on only one side of the parachutist.

Furthermore, DOT/FAA/AM-98/11 demonstrated that the use of a single seat belt anchor point caused the parachutist’s torso to rotate relative to the aircraft’s direction of movement during the impact.

Accordingly, it was observed that during the collision, the parachutists were subjected to forces converging toward the center of the aircraft, as well as forward. Regarding the parachutists' positioning at the time of impact, it was found that both parachutists seated in the first row (closest to the front of the aircraft) had their backs off their respective backrests.

Thus, it was observed that the arrangement and securing of the parachutists inside the aircraft contributed to some of them being thrown forward during the impact, increasing the dynamic loads applied to the seat belts and their attachment brackets.

Therefore, it was inferred that the securing methods used in the occurrence under investigation—using only one seat belt—while practical and simple, may not have provided the same level of restraint as other securing methods, such as dual seat belts.

Concerning structural protection of aircraft occupants, the RBAC-23 stipulated that an airplane, even when damaged in an emergency landing, must protect each occupant from injuries that would prevent them from evacuating the aircraft.

For this reason, considering that most of the passengers' seat belts failed due to shearing of their attachment brackets and that some rings broke from overload, in addition to the tearing of certain belt fabrics, it was concluded that the seat belts did not comply with the requirements set forth in RBAC-23 and contributed to the injuries sustained by the parachutists during the emergency landing.

3. CONCLUSIONS.

3.1. Findings.

a) the pilot held a valid CMA (Aeronautical Medical Certificate);

b) the pilot held valid MNTE and IFRA ratings;

c) the pilot had qualification and experience for the type of flight;

d) the aircraft had a valid CVA (Certificate of Airworthiness);

e) the aircraft was within weight and balance limits;

f) the aircraft had been modified, and approved by ANAC, for parachute drop operations in 2011;

g) a subsequent modification, which included the installation of seats for parachutists, among other items, was not incorporated into the aircraft records;

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

i) the aircraft manual prohibited the use of the Emergency Power Lever (EPL) when the primary power lever was not in the IDLE position;

j) some of the pilots would check whether the EPL lever had full travel during pre-start checks;

k) it was reported that the EPL lever was used in flight during emergency landing training;

l) there were 15 parachutists on board the aircraft;

m) the meteorological conditions were above the minima required for the flight;

n) the bleed valves had control pressure limits slightly below those specified in the manual;

o) the results of the fuel and engine oil samples were within their respective specifications and showed no signs of contamination;

p) flames were seen coming from the left engine exhaust during the emergency landing;

q) the ITT was operated at temperatures close to the physical limit of its indicator;

r) the emergency landing occurred off-airfield, in a rural area;

s) after the impact, all occupants of the aircraft were thrown forward in the cabin;

t) some of the seat belt attachment fittings showed signs of corrosion;

u) some of the seat belts detached from the aircraft;

v) all seat belt attachment points consisted of a single pin;

w) one parachutist was ejected through the aircraft windshield;

x) the seat belts did not meet the requirements established in the RBAC-23;

y) the aircraft sustained substantial damage;

z) two passengers were fatally injured;

aa) the pilot and four passengers were seriously injured;

bb) four passengers received minor injuries; and

cc) five passengers were not injured.

3.2. Contributing factors.

- **Training – undetermined.**

The frequent and improper use of the EPL during emergency landing training throughout the aircraft's operation may have contributed to engine degradation.

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

The recurring improper use of the EPL by multiple pilots during the operation of the aircraft may have contributed to engine degradation.

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

It is possible that the pilot's use of the aircraft’s EPL was inappropriate and contributed to the severity of the accident.

- **Aircraft maintenance – a contributor.**

Given the large number of seatbelts that detached as a result of the shearing of their floor attachment brackets and their corroded condition, it was determined that the maintenance actions were not effective in ensuring the integrity and reliability of these materials, which contributed to the injuries sustained by the parachutists during the emergency landing.

- **Managerial oversight – a contributor.**

The oversight of the operational procedures related to the use of the EPL was not effective in identifying the risks associated with its use in disagreement with the aircraft manufacturer’s specifications.

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-063/CENIPA/2022 - 01 **Issued on 07/03/2025**

Disseminate the lessons learned from this investigation to operators of the Cessna 208 model aircraft, in order to raise awareness of the risks associated with the improper use of the Emergency Power Lever (EPL), given the potential to aggravate an emergency situation.

A-063/CENIPA/2022 - 02 **Issued on 07/03/2025**

Engage with *Skydive4fun Serviço Aéreo Especializado Ltda.* to ensure that its aircraft are operated and maintained in full compliance with applicable manuals and regulations, particularly regarding the use of the EPL and the maintenance of seat belts.

A-063/CENIPA/2022 - 03 **Issued on 07/03/2025**

Engage with Air Operator Certificate holders conducting commercial parachute drop operations to ensure that maintenance actions—both planned and executed—comply with the actual configuration of each aircraft.

A-063/CENIPA/2022 - 04 **Issued on 07/03/2025**

Engage with CONAL AVIONICS Maintenance Organization (COM 9012-08/ANAC) to ensure that maintenance is carried out strictly in accordance with applicable manuals and technical documentation, taking into account the actual configuration of the aircraft fleet, especially those registered under the Specialized Air Service – Parachuting (SAE-PQD) category.

5. CORRECTIVE OR PREVENTATIVE ACTION ALREADY TAKEN.

None.

On July 3rd, 2025.