COMANDO DA AERONÁUTICA

CENTRO DE INVESTIGAÇÃO E PREVENÇÃO DE ACIDENTES AERONÁUTICOS

FINAL REPORT
A - 095/CENIPA/2017

OCCURRENCE:	**ACCIDENT**
AIRCRAFT:	**PR-PRF**
MODEL:	**SR20**
DATE:	**20JUL2017**

NOTICE

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

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

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

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

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

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

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

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

SYNOPSIS

This is the Final Report of the 20JUL2017 accident with the SR20 aircraft model, registration PR-PRF. The accident was classified as “[SCF-PP] System/Component Failure or Malfunction Powerplant – Engine Failure in Flight and [LOC-I] Loss of Control in Flight”.

Shortly after the take-off, the aircraft's engine lost power and the pilot began a sharp left turn and at low altitude, lost altitude and crashed into the ground.

The aircraft was destroyed.

The pilot and passenger suffered fatal injuries.

An Accredited Representative of the National Transportation Safety Board (NTSB) - USA, (State where the aircraft was manufactured) was designated for participation in the investigation.

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GLOSSARY OF TECHNICAL TERMS AND ABBREVIATIONS

AGL	Above Ground Level
AMR	Materials Division
ANAC	Brazil’s National Civil Aviation Agency
AvGAS	Aviation Gasoline
CA	Airworthiness Certificate
CAPS	Cirrus Airframe Parachute System
CCF	Physical Capacity Certificate
CENIPA	Aeronautical Accident Investigation and Prevention Center
CIV	Pilot`s Flight Logbook
CMA	Aeronautical Medical Certificate
DCERTA	Correct Take-off Computerized System - ANAC
ELT	Emergency Locator Transmitter
EPTA	Telecommunications and Air Traffic Service Provider Station
HRC	Rockwell Hardness Scale
IAE	Aeronautics Space Institute
IAM	Annual Maintenance Inspection
IFR	Instrument Flight Rules
IFRA	Instrument Flight Rating - Airplane
METAR	Aviation Routine Weather Report
MEV	Scanning Electron Microscope
MNTE	Airplane Single Engine Land Rating
NTSB	National Transportation Safety Board
PCM	Commercial Pilot License – Airplane
PIC	Pilot in Command
POH	Pilot’s Operating Handbook
PPR	Private Pilot License - Airplane
RBHA	Brazilian Aeronautical Certification Regulation
SACI	Integrated Civil Aviation Information System
SBPP	ICAO Location Designator – Ponta Porã Aerodrome - MS
SBRD	ICAO Location Designator – Maestro Marinho Franco Aerodrome, Rondonópolis - MT
SPECI	Selected Special Aeronautical Weather Report
SWRS	ICAO Location Designator – Santa Mônica Farm Aerodrome, Santo Antônio do Leverger - MT
TPP	Registration Category of Private Service - Aircraft
UTC	Universal Time Coordinated
VPD	Velocity of Parachute Deployment

1. FACTUAL INFORMATION.

Aircraft	**Model:** SR20 **Registration:** PR-PRF **Manufacturer:** Cirrus Design	**Operator:** Private
Occurrence	**Date/time:** 20JUL2017 - 1100 UTC **Location:** Santa Edwiges Farm **Lat.** 16°41'10"S **Long.** 055°08'20 **Municipality – State:** Santo Antônio do Leverger – MT	**Type(s):** "[SCF-PP] System/Component Failure or Malfunction Powerplant [LOC-I] Loss of Control in Flight". **Subtype(s):** Engine Failure in Flight

1.1 History of the flight.

The aircraft took off from an unregistered area, located at Santa Edwiges Farm, rural area of the municipality of Santo Antônio do Leverger - MT, to the Ponta Porã Aerodrome (SBPP) - MS, at about 1100 (UTC), in order to transport personnel, with a pilot and a passenger on board.

Shortly after the take-off, an observer saw black smoke coming out of the engine's exhaust and then heard a characteristic noise of loss of power. Then, he watched the aircraft begin a low altitude turn, to the left side, coming to impact against the ground.

The aircraft was destroyed.

The pilot and the passenger suffered fatal injuries.

1.2 Injuries to persons.

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

1.3 Damage to the aircraft.

The aircraft was destroyed.

1.4 Other damage.

None.

1.5 Personnel information.

1.5.1 Crew's flight experience.

Flight Hours	Pilot
Total	Unknown
Total in the last 30 days	23:05
Total in the last 24 hours	01:05
In this type of aircraft	Unknown
In this type in the last 30 days	23:05
In this type in the last 24 hours	01:05

N.B.: It was not possible to determine the total flight hours by the PIC, since the Investigation Team did not obtain access to the pilot's physical CIV. In the digital CIV, available in the SACI of the ANAC, a total of 84 hours and 28 minutes were recorded, all of them performed in single-engine aircraft. Also, the Logbook and the DCERTA were used to calculate the hours flown.

1.5.2 Personnel training.

The PIC took the PPR course in October 2006.

1.5.3 Category of licenses and validity of certificates.

The PIC had the PCM License and had valid MNTE and IFRA Ratings.

1.5.4 Qualification and flight experience.

The pilot was qualified and, according to interviews, he had been piloting light single-engine aircraft for over ten years.

He operated the PR-PRF for approximately four months.

1.5.5 Validity of medical certificate.

The PIC had valid CMA.

1.6 Aircraft information.

The aircraft, serial number 1064, was manufactured by Cirrus Design in 2000 and was registered in the TPP Category.

The aircraft CA was valid.

According to the CA, the aircraft had the capacity to carry three passengers, one crewmember and was certified to operate with only one pilot.

The airframe, engine and propeller logbooks records were updated.

The last inspections of the aircraft, the “100 hours/IAM” type, were carried out on 19MAY2017, by the Maintenance Organization *América do Sul Serviços Aeronáuticos*, in Sorocaba - SP. Considering the last register in the Logbook, dated 16JUL2017, the aircraft flew, after inspection, a total of 43 hours and 54 minutes.

The engine that equipped the PR-PRF aircraft was the IO-360-ES-16B model, with serial number 1032130, and was reconditioned (engine rebuilt) by Continental Motors Inc. This engine had approval for use, both by the civil aviation of the manufacturer`s country and by the ANAC, being in accordance with the requirements for the certification of aeronautical product.

It was acquired from the manufacturer by JP *Martins Aviação* Ltd., an aeronautical company based in the city of São Paulo, having been installed in the PR-PRF in March 2016.

According to the components map, the fuel pump that came installed next to the engine had the serial number B16BA164R and Part Number 649368-74A4, having been installed on the aircraft on 09MAR2016.

The reconditioned/rebuilt engine was considered as new, in accordance with the provisions of the RBHA No. 91, item 91.421, letters "a" and "c", in force at the time of the occurrence:

> (a) The owner or operator may use a new maintenance record, without previous operating history, for a conventional engine rebuilt by the manufacturer or by a shop approved by the manufacturer.
>
> [...]
>
> (c) For the purposes of this section a rebuilt engine is a used engine that has been completely disassembled, inspected, repaired as necessary, reassembled, tested and approved in the same manner and to the same tolerances and limitations as a new engine, using new or used. However, all used parts must conform to the

tolerances and limits of new parts or approved under- or over-sized dimensions for a new engine.

[...]

The engine and fuel pump assembly had approximately 153 flight hours after being overhauled.

General Characteristics of the Cirrus SR20 Aircraft Fuel System

The fuel system is intended to supply fuel for normal engine operation. The system consisted of an integral, vented fuel tank with a capacity of 30.3 gallons (28 usable gallons) on each wing, a fuel collector/reservoir on each wing, a three-position selector valve, an electric booster pump and an engine-driven fuel pump.

Fuel was gravity fed and flowed from each tank to associated collecting reservoirs, where the engine-driven pump sucked fuel through a selector valve and filter to feed the engine's injection system. The electric booster pump was intended to assist in starting the engine and to eliminate fuel vapors.

The engine-driven pump sucked the filtered fuel from the two collection tanks through a three-position selector valve (LEFT-RIGHT-OFF). The selector valve allowed the pilot to choose one of the two tanks to supply the system or none of them by keeping it closed.

From the pump driven by the engine, the fuel was proportionately dosed, sent to a flow divider and directed to the cylinders. Excess fuel was returned to the respective tank.

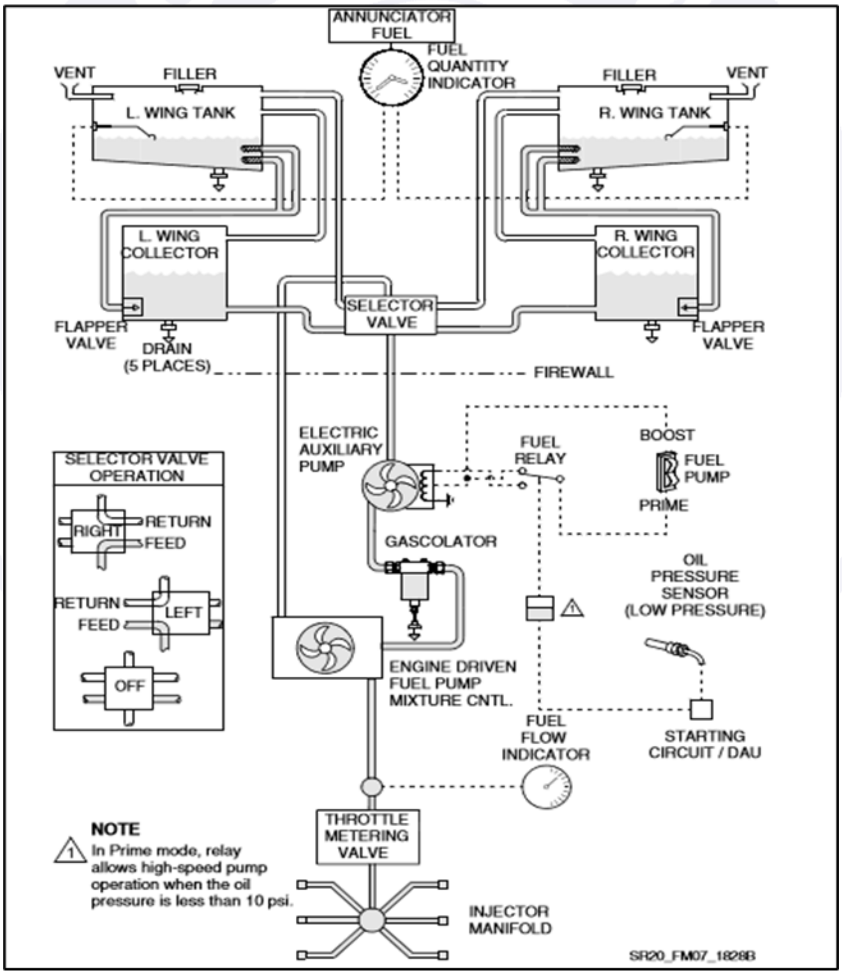

Figure 1 - Schematic representation of the Cirrus SR20 aircraft fuel system.

Cirrus Airframe Parachute System (CAPS) Features

The Cirrus aircraft, model SR 20 or SR 22, had a parachute triggering system called Cirrus Airframe Parachute System (CAPS) whose activation was done by pressing down a red lever located above the pilot's shoulder. As stated in the CAPS guide, available on the manufacturer's website: "Cirrus pilots need to train so that they are capable and conditioned to use the parachute when necessary". According to the manufacturer's manual, the device could be activated in an emergency, but required the aircraft to be below its VPD, which in the case of the SR 20 would be 133 kt, and at a minimum altitude of 400 ft.

This guide contains the following information about possible CAPS triggering situations:

> The CAPS should be activated in the event of a life-threatening emergency situation, where its use is recommended as being safer than attempting to maintain the flight to land.
>
> Loss of control:
>
> Loss of control is a situation in which the aircraft does not respond as the pilot expects and may be the result of a control or system failure, turbulence, disorientation, icing or loss of situational awareness on the part of the pilot. If a loss of control occurs, the CAPS must be activated immediately.
>
> Engine failure (out of runway range):
>
> If a forced landing is required on any surface other than a runway, activating the CAPS is highly recommended. So also, in situations of forced landing in terrains such as: mountains, water, under fog, at night, or in IMC conditions.
>
> Engine failure (within runway range):
>
> In the event of an engine failure within a glide distance to a runway, the pilot must continually assess the situation. At 2,000 ft AGL, if the landing is guaranteed, the pilot can proceed to the runway. Otherwise, you must activate the CAPS. At 1,000 ft AGL, if landing is still guaranteed, the pilot can continue to recognize that the risks of getting too high or too low or losing control of the aircraft at low altitude are likely to outweigh the risks of a CAPS activation at the right time. If landing is not guaranteed until at least 400 ft AGL, the pilot must trigger the CAPS immediately.
>
> Pilot Incapacitation:
>
> Pilot incapacitation can occur for a variety of causes, ranging from a pilot's medical problem to even a bird strike that injures the pilot. If such a situation arises and no passenger has been trained to land the aircraft, the use of the CAPS is highly recommended.
>
> Collision in the air:
>
> A mid-air collision will likely cause the aircraft to become uncontrollable, due to damage to the control cables or the aircraft structure. Unless it is evident that neither the controls nor the structure of the aircraft have been affected, the use of the CAPS is highly recommended.
>
> Structural failure:
>
> A structural failure has never occurred on a Cirrus aircraft. However, if it does occur, activating the CAPS is highly recommended.

Regarding the speed and altitude to activate CAPS, the guide mentions that:

> The maximum speed shown for the parachute activation is not meant to be a limitation, just as, for example, the maximum crosswind speed is not. The VPD is the speed at which the CAPS was demonstrated during its homologation. The parachute proved to withstand being deployed at 165 kts during extreme drop tests. These tests were carried out with 125% of the aircraft's maximum take-off weight, that is, it is possible that the parachute can support activations at even higher speeds. There have been several cases of successful CAPS activation at speeds above VPD.

> No minimum or maximum altitude has been defined for activating the CAPS. This is because the actual loss of altitude during any activation depends on the aircraft's attitude, altitude and speed, as well as other meteorological factors. The altitude loss during the CAPS opening depends primarily on the direction the aircraft is maintaining at the time of activation. If the parachute is deployed in a level attitude, much of the deceleration occurs over a horizontal distance, minimizing the loss of altitude. If the parachute is activated on a vertical descent, deceleration occurs over a vertical distance, when altitude loss is maximum.
>
> If possible, the pilot should activate the CAPS with sufficient time and altitude for a successful activation; thus, the decision to activate must be taken as soon as possible. The pilot must have a minimum altitude in mind to activate the CAPS. If the CAPS is activated too close to the ground, the chances of a successful activation decrease dramatically. Whenever the pilot is in a situation where there is no other alternative for survival, the CAPS must be used regardless of altitude.

The manufacturer made available to pilots, on its website (https://learning.cirrusapproach.com/learning-catalog), free training on CAPS.

In a survey carried out in the SIPAER Panel, 22 occurrences classified as accidents or serious incidents involving Cirrus model SR20 and SR22 aircraft in Brazil were identified. Of this total, 18 were classified as accidents and 4 as serious incidents. Of the occurrences classified as accidents, 2 were of the “Loss of control in flight” type and 4 of the “Engine failure in flight” type. In the 2 occurrences of the type “Loss of control in flight”, only one was the CAPS activation, but without success (PR-ETJ on 21OCT2019). In the 4 occurrences of the “In-flight engine failure” type, only one was the CAPS activation, which was successfully performed (PR-LVB on 14NOV2013). Of the 4 serious incidents, 1 was classified as "In-flight engine failure", in which the CAPS was also successfully activated (PP-CIE on 24MAR2012).

1.7 Meteorological information.

There was no aeronautical meteorological service available for the aircraft's take-off location. As a reference, meteorological information was collected from the Maestro Marinho Franco Aerodrome (SBRD), Rondonópolis - MT, 25 NM away from the accident site, which were obtained through the website www.redemet.aer.mil.br.

It was not possible to record the weather conditions for the time of the accident, given that the SBRD's EPTA was out of its operating hours. However, the SPECI and the METAR of SBRB, from 1230 (UTC), that is, 1 hour and thirty minutes after the time of the accident, indicated favorable weather conditions for visual flight, as described below:

> SBRD SPECI 20/07/2017 1200 SBRD 201230Z 08005KT CAVOK 18/05 Q1021
>
> SBRD METAR 20/07/2017 1300 SBRD 201300Z 08005KT CAVOK 19/06 Q1021
>
> SBRD METAR 20/07/2017 1400 SBRD 201230Z 07007KT CAVOK 21/08 Q1021

This information could be corroborated through the voluntary report provided by a pilot who was at the threshold of the area used for take-off by the PR-PRF, who stated that the visibility and ceiling conditions allowed the flight to be conducted under visual meteorological conditions.

1.8 Aids to navigation.

Nil.

1.9 Communications.

Nil.

1.10 Aerodrome information.

The occurrence took place out of the Aerodrome.

Despite having dimensions and physical characteristics compatible with the intended operation, the area used for take-off was not registered and it was located on a private property in the countryside.

The area was grassy, with a regular surface, 180º/360º magnetic bearings, dimensions of 1,200 x 30 m and an elevation of 575 ft. In the approach sector, in the 360º direction, there was a house and a hangar, about 50 meters away.

The entire length of the area was fenced off. In the extension of the axis in the 360º direction, in an area beyond that delimited for use during landings and take-offs, there were a few trees, being, in general, free of natural and artificial obstacles, presenting soft and flat terrain.

1.11 Flight recorders.

Neither required nor installed.

1.12 Wreckage and impact information.

The take-off and the collision of the aircraft with the ground were observed by a person who was approximately 1,620 meters away from the accident site.

The impact occurred at a point 420 meters away from the area used for take-off, and the distribution of the wreckage was of the concentrated type.

The first point of impact of the aircraft against the ground was twenty-three meters away from the place where the wreckage was concentrated. The right main landing gear opened a small hole in the ground, then detached and projected forward, in the direction of displacement (Figure 2). There was also the detachment of the nose gear wheel, which remained close to the wreckage. The final stopping position of the aircraft was with the nose pointing to the 353º magnetic heading.

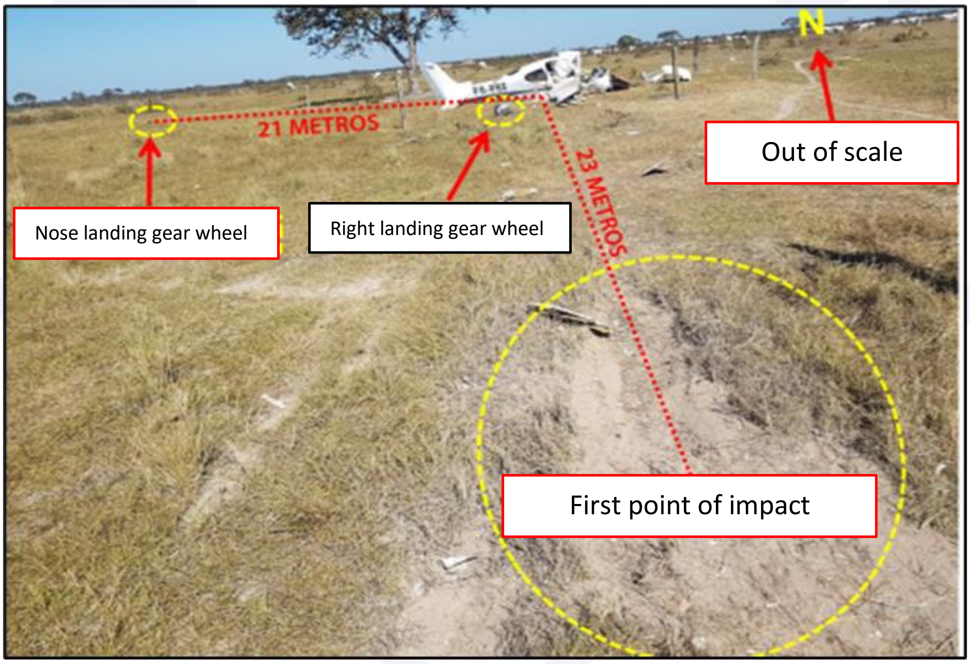

Figure 2 - First point of impact and distribution of the wreckage.

The right wing was destroyed, as was the central coffin that held the fuel tank (Figure 3). The left wing was damaged, and the flaps corresponded to the 100% lowered position (Figure 4).

Figure 3 - General view of the wreckage. Cabin and right wing destroyed.

Figure 4 - Left wing flaps fully deflected.

The left aileron was down and the right aileron was completely destroyed. The horizontal stabilizer suffered minor damage, showing a dent on its right side. The vertical stabilizer and the rudder were not damaged, the latter with a small deflection to the left side.

The coupling flange between the engine and the propeller was broken. Two of the three propeller blades were slightly bent backwards, and the other was bent forward, halfway along its length. The propeller assembly was found under the aircraft cabin (Figure 5).

Figure 5 - Propeller set detached and found under the fuselage, with folding blades.

The cockpit had the greatest degree of destruction. The instrument panel was badly damaged, the front seats were projected forward and with a slight inclination to the right side.

In the central console, the following was observed: flap selector commanded to the “100%” position; throttle at half stroke; fuel lever (mixture) in poor position, fuel pump in boost position; and fuel selector valve commanded for the left tank (left), as shown in Figure 6.

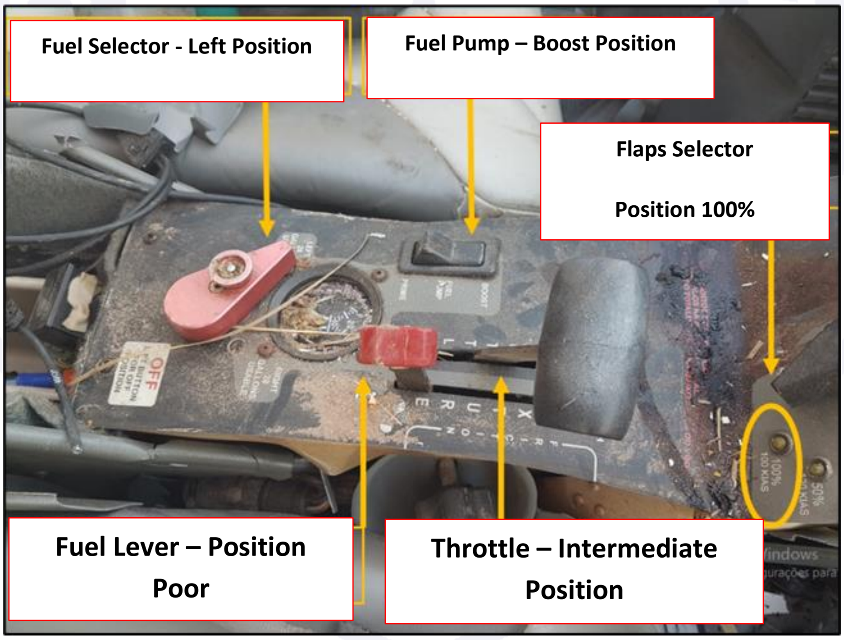

Figure 6 - Central console and lever pedestal in the cockpit.

The Fuel Pump and Standby Vacuum circuit breakers were tripped in the circuit breaker panel, as shown in Figure 7.

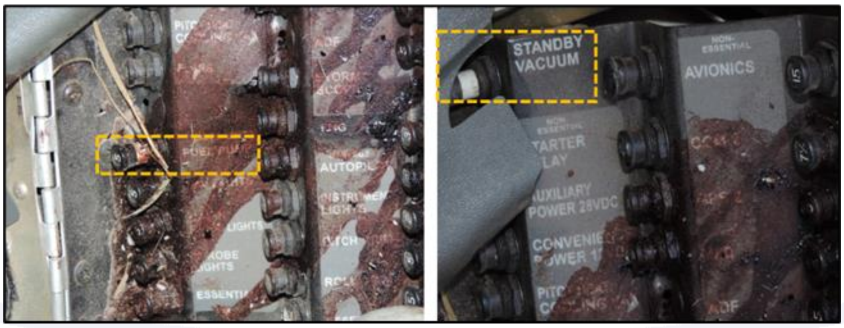

Figure 7 - Circuit breaker panel. The Fuel Pump (left side) and Standby Vacuum (right side) circuit breakers are highlighted.

The ELT switch was in the ARM position. Some of the switches present in the aircraft's GPS equipment were dented up and to the right side.

The protective cover of the trigger handle of the ballistic parachute, which equipped this type of aircraft, was loose amidst the wreckage of the cabin and the parachute was in its housing, intact.

In a visual inspection carried out through the fuel supply nozzle located on the left wing, no remaining fuel was found. However, in the vicinity of the wreckage, it was possible to smell a characteristic odor of aviation gasoline (AvGas). No evidence or spread of fire was found.

1.13 Medical and pathological information.

1.13.1 Medical aspects.

The pilot and passenger were removed from the aircraft by residents of the farm and transported by plane to SBRD, where they received the first medical care from the Emergency Medical Service (SAMU) team, about thirty minutes after the accident.

The doctor who was treating the victims found that the pilot had died. The other occupant was taken to the Sister *Elza Giovanella* Regional Hospital, with serious injuries, and died on 22JUL2017, two days after the accident, due to the severity of the injuries.

It was not possible to identify physiological or incapacitating weights that affected the crewmember's performance and contributed to the accident.

1.13.2 Ergonomic information.

Nil.

1.13.3 Psychological aspects.

The pilot had been flying the PR-PRF aircraft for almost four months.

It was found that there was no work routine previously established for the pilot, and his work was carried out on demand. According to reports from people close to the pilot, he had been complaining about a “hectic routine”.

Based on reports from coworkers, the day before the accident, the pilot went to sleep around 10:00 pm (local), having woken up at 05:00 am (local) the next day. After having breakfast, he followed with another pilot who was at the farm that day to the hangar where the aircraft was parked, in order to start the preflight inspections.

There was no evidence that psychological, or disability issues had a direct role in the occurrence.

1.14 Fire.

There was no fire.

1.15 Survival aspects.

According to the report by one of the farm workers who helped to provide assistance to the victims, the occupants of the aircraft were wearing seat belts. According to information provided by one of the rescuers, they were taken out of the cockpit still alive.

1.16 Tests and research.

The aircraft, whose maximum take-off weight was 1,315 kg, was equipped with a conventional IO-360-ES (16) engine, serial number 1032130, with 200 HP of power, manufactured by Continental Motors.

Due to the signs of failure or malfunction of the aircraft engine, it was preserved for the purpose of examination and technical analysis.

The engine opening work was carried out on 12DEC2017, with the presence of the Investigator in Charge of this occurrence, an Investigator from the DCTA, a representative from Continental Motors and another from the aircraft insurer.

Disassembly and inspection of the engine revealed that:

- the aircraft engine suffered a frontal impact, which caused the breakage of the crankshaft, in the coupling flange with the propeller;
- the propeller blades did not suffer major deformations resulting from the impact;
- the spinner presented localized deformation;
- the spark plugs had a large amount of lubricating oil. The left and right magnets were sparking, indicating a normal operating condition;
- the oil filter was clean and free of filings. The engine lubricating oil pump was tested and showed normal operation, with no signs of filings passing through its gears or its body. Likewise, in the oil sump, nothing was found that could provide indications that any internal component of the engine was malfunctioning;
- no risks were identified on the cylinders and pistons that could indicate the occurrence of detonation or any other abnormal condition that could cause the engine to malfunction;
- the camshaft did not show abnormal wear that could contribute to the engine malfunction;
- no anomalies were found in the crankshaft that would indicate excessive wear on its trunnions and journals. Dynamic counterweights were normal. All connecting rods had normal slip and no excessive looseness was observed;
- no anomaly was observed in the semi-carcasses. The bearings had normal appearance, color and wear from work;
- all injectors were clear. No anomaly was found in the internal components of the fuel distributor, as well as in the fuel metering valve, which could have contributed to an irregular operation or loss of engine power;
- the fuel filter was free of any contamination that could block the flow of fuel;
- the electric fuel pump was tested on another aircraft and showed normal operation, according to the tests prevised in the operation manual;
- the fuel pump drive shaft was found with a fracture at its end, as seen in Figure 8.

Figure 8 - General view of the fuel pump. Highlighted on the right are photos of the drive shaft and the fracture surface at its end. Left highlight shows observed damage to pump retainer and connection.

A fracture was found at the end of the shaft (Figure 9). The fracture surfaces indicated the presence of a pre-crack region followed by a torsional overload failure region.

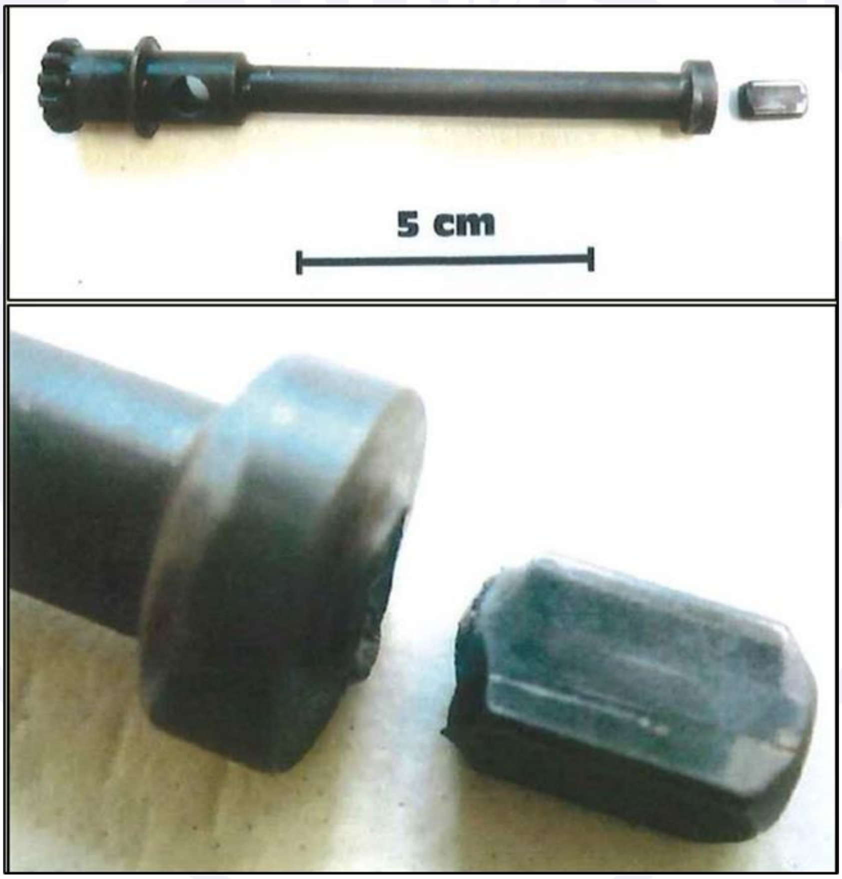

Figure 9 - Engine fuel pump drive shaft with fracture at its end.

The MEV examinations confirmed the presence of pre-crack, as seen in Figures 10 and 11, and revealed a fragile fracture aspect in this region, due to the cleavage and intergranular fracture mechanisms.

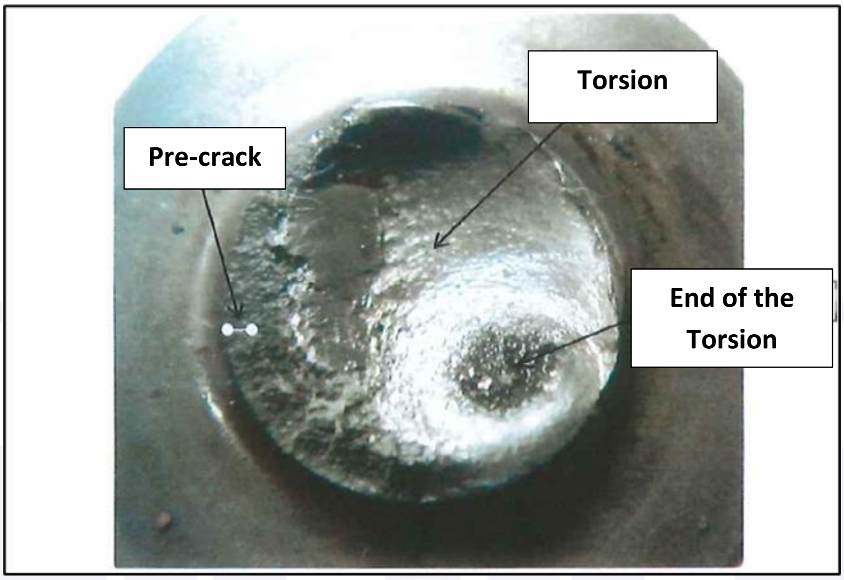

Figure 10 – Stereography showing the fracture surface of the fuel pump shaft, with the presence of pre-crack and rupture by torsion.

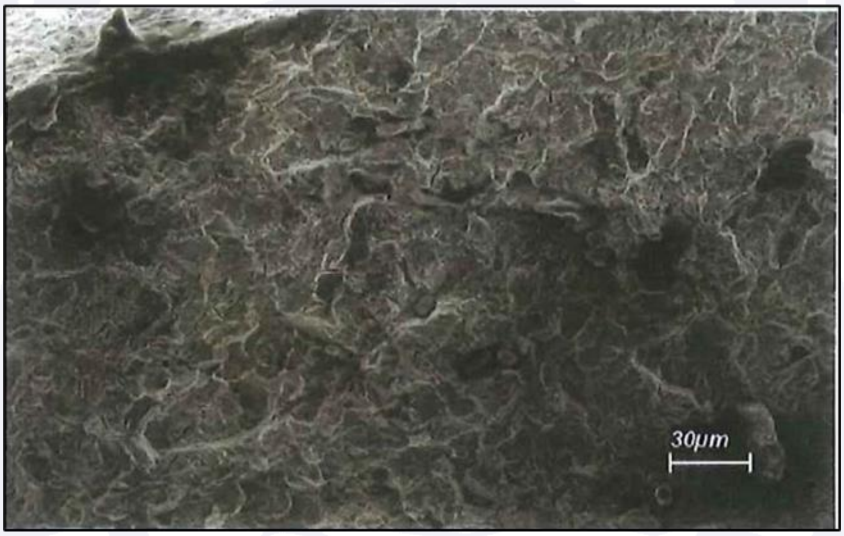

Figure 11 – Electro micrograph showing the fragile aspect of the fracture, with cleavage and intergranular mechanisms.

Chemical analyzes and measurements of Rockwell C hardness and Vickers microhardness profiles converted to Rockwell C were performed on a similar fuel pump shaft, removed from use and not fractured, and on the fractured part for comparison of results. The chemical compositions obtained were similar, indicating that the two pieces were made of steel 8640, in accordance with SAE/AISI standards.

The HRC measurements were performed in the central region of the rods and represented the average of five measurements. Vickers microhardness measurements converted into HRC were performed with a spacing of 0.1 mm. It was observed that, in the fractured part, the hardness drops rapidly, from 0.5 mm below the surface of the part to the center, while in the unfractured part, the hardness remained similar, from the surface to the center of the part.

The metallographic analysis of the fractured part in the section perpendicular to the fracture, without attack, indicated a flat region of approximately 0.5 mm, corresponding to the pre-crack, and another concave region, corresponding to the fracture by torsion.

Based on the results obtained, it was possible to conclude that the fracture of the fuel pump shaft initially occurred in a fragile way, with the formation of a pre-crack of approximately 0.5 mm, followed by a ductile fracture by torsion.

Comparing the material of the fractured shaft with the other removed from use and not fractured, it was found that, despite the material being the same for both shafts, that is, steel AISI 8640, differences were observed in relation to hardness and microstructure of the axes. These differences seem to indicate that the broken shaft underwent an abnormal heat treatment that facilitated its fracture in service.

1.17 Organizational and management information.

Nil.

1.18 Operational information.

The aircraft had a private use, according to its category, for the transport of the operator. The flights performed by the pilot occurred as a single pilot, that is, with the aircraft being manned by only one pilot. According to the information obtained, as it is an aircraft whose operating requirements established the minimum crew of a pilot, the operator was not interested in hiring a Second in Command (SIC).

Furthermore, it was found that the owner, who was a passenger and occupied the right front seat, had a PPR License since September 1979. He had his MNTE Rating expired since December 1985 and his CCF was expired since February 1980.

According to the report of the pilot who accompanied the inspections, the pre-flight was carried out in full, but without reading and monitoring the POH, Section 4, Normal Procedures, Preflight-Walk Around Inspection. This procedure contemplated the verification of eighty-two items, which, according to the report collected, were carried out from memory by the pilot.

No flight plan was presented. However, as stated in interviews, the intended flight consisted of taking off from the area of Santa Edwiges Farm and landing on SBPP.

To this end, the distance of 352 NM would be covered in approximately 2 hours and 17 minutes, taking into account the throttle setting at 75%, speed of 155 kt, zero wind and FL 080, as described in Section 5 of the POH

The fuel supply was carried out on 18JUL2017, at 1940 (UTC), in SBRD. According to the supply receipt, it was found that the aircraft was filled with 165 liters of aviation gasoline (43.6 U.S. GAL).

Considering the hourly consumption described in Section 5 of the POH Range/Endurance Profile of 11.6 Gallons per hour, approximately 26 U.S. GAL, or 100 liters, would be required for the intended flight.

An analysis of the records contained in the DCERTA system showed that the aircraft's flight plans used the Santa Mônica Farm Aerodrome (SWRS), in Santo Antônio do Leverger - MT, about 20 NM away from the area used in the Santa Edwiges Farm as a departure or destination.

According to reports, starting the engine and taxiing the aircraft to the area used took place without any abnormality. Shortly after the take-off, with the aircraft at about 50 ft in height, a pilot who was on the ground and near the end of the area observed black smoke being expelled from the exhaust, followed by a characteristic sound of loss of power from the aircraft engine. This same characteristic sound was reported by another observer who was inside a house located in the vicinity of the area.

An analysis of Section 5 of the POH provided an approximate take-off distance of 470 meters, considering a dry grass runway, take-off weight of 2,790 lbs, temperature of 20º C, airfield altitude of 575 ft and wind null.

Upon reaching 50 ft after the take-off, when the first signs of engine failure or malfunction were perceived, the aircraft had traveled around 565 meters of the available area, leaving 635 meters ahead. As predicted in the performance graph for the total landing distance, this remaining length would still be enough for the aircraft to perform a forward landing and a full stop.

In the case of Engine Failure on Takeoff - Low Altitude, it was provided in Section 3, Emergency Procedures, of the POH, that, if there was no possibility of restarting the engine, the pilot should lower the nose of the aircraft, in order to establish an attitude and glide speed.

In addition, it established that the landing should be made in a field just ahead, with a curve only to avoid obstacles, performing as much of the items on the checklist as possible. If the decision was to return to the runway, this maneuver should be performed with care that the aircraft does not enter a stall condition, as shown in Figure 12.

Cirrus Design
SR20

Section 3
Emergency Procedures

In-Flight Emergencies

Engine Failure On Takeoff (Low Altitude)

If the engine fails immediately after becoming airborne, abort on the runway if possible. If altitude precludes a runway stop but is not sufficient to restart the engine, lower the nose to maintain airspeed and establish a glide attitude. In most cases, the landing should be made straight ahead, turning only to avoid obstructions. After establishing a glide for landing, perform as many of the checklist items as time permits.

• WARNING •

If a turn back to the runway is elected, be very careful not to stall the airplane.

1. Best Glide or Landing Speed (as appropriate) .... ESTABLISH
2. Mixture .... CUTOFF
3. Fuel Selector .... OFF
4. Ignition Switch .... OFF
5. Flaps .... AS REQUIRED

If time permits:

6. Power Lever .... IDLE
7. Fuel Pump .... OFF
8. Bat-Alt Master Switches .... OFF
9. Seat Belts .... ENSURE SECURED

Figure 12 - Emergency procedures for engine failure shortly after takeoff, at low altitude, as established by the manufacturer's manual.

An analysis of the area adjacent to the one used for the take-off allowed us to conclude that, in addition to the extension of the axis used, there were a few trees, being, in general, free of natural and artificial obstacles, with a flat terrain and without many irregularities, presenting, therefore, conditions favorable to the accomplishment of the landing ahead.

At about 200 ft high, the aircraft was spotted drifting slightly to the right of the take-off axis and then executing a sharp left turn (approximately 60 degrees of bank) while losing height. Also, according to the report, when very close to the ground, the aircraft performed a wing turn to the right and collided with the ground at a distance of 420 meters from the end of the area used for takeoff.

The CAPS was not activated, as recommended by the manufacturer in its Guide (Figure 13).

Altura sobre o solo (AGL)	Ação recomendada
0' – 500' (600' G5)	Pouse em frente*
500' (600' G5) – 2000'	Acione o CAPS imediatamente
2000' or Greater	Pesquisa de pane, use o CAPS conforme requerido

*Activate the CAPS immediately if there is no other survival alternative.
Figure 13 - Recommended actions for using CAPS.

The wreckage analysis allowed us to state that the aircraft was with the flaps at 100% position, it is estimated that the speed at the moment of the turn was of the order of 75 KIAS (speed to clear obstacles at 50 ft) to 85 KIAS (speed of retract flaps) or less, taking into account the expected speeds during normal operation, as described in Section 4 of the POH (Airspeed for Normal Operations).

As stated in the aircraft operating manual, Section 5, Stall Speeds, the stall speeds were presented as a function of the position of the Center of Gravity, position of the flaps and angle of inclination (Figures 14). Also, according to the manual, the altitude lost during a stall condition, with leveled wings, was 250 ft or more, this condition being aggravated when performing a turn.

Weight	Bank Angle	STALL SPEEDS					
		Flaps 0% Full Up		Flaps 50%		Flaps 100% Full Down	
LB	Deg	KIAS	KCAS	KIAS	KCAS	KIAS	KCAS
3000 Most FWD C.G.	0	65	67	61	63	56	59
	15	66	68	62	64	57	60
	30	70	72	65	68	61	63
	45	78	80	72	75	67	70
	60	92	95	86	89	80	83
3000 Most AFT C.G.	0	64	66	59	62	54	57
	15	65	67	60	63	55	58
	30	69	71	64	66	58	61
	45	76	78	71	73	64	68
	60	90	93	84	87	76	81

Figure 14 - Cirrus SR20 aircraft stall speeds. Highlighted, speeds for the 60-degree wing pitch condition.

The Airplane Flying Handbook, published by the FAA, 2016 revision, stated in the topic Engine Failure After Takeoff (Single Engine Airplane) that the available height was, in many cases, the factor of success in carrying out a landing. and it would be safer to immediately establish the appropriate glide attitude by selecting a field directly ahead or slightly to the side of the take-off trajectory, it being inadvisable to attempt to return to the field from which the take-off took place.

Based on what the aircraft flight manual recommended in relation to the maximum glide ratio (10.9:1), with the aircraft at 200 ft AGL, following the procedures and conditions established by the manufacturer for an engine failure, it was possible that the aircraft could fly ahead at a ground clearance approaching 0.35 NM (660 meters), as shown in Figure 15.

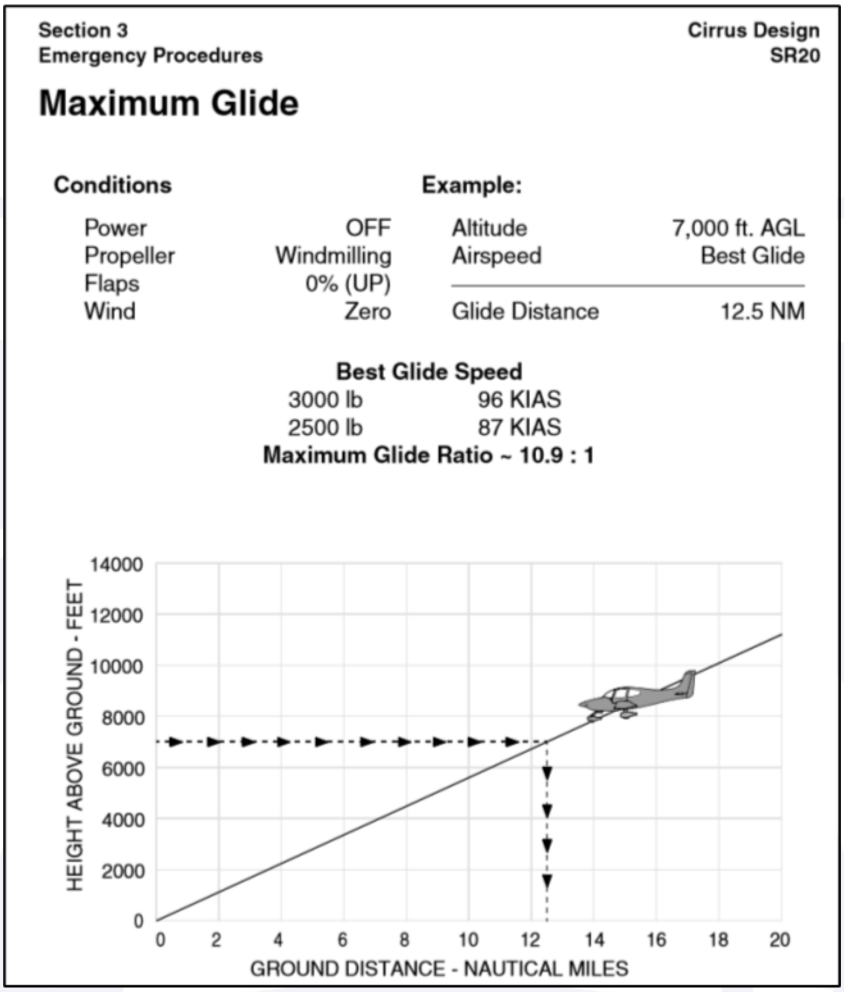

Figure 15 - Maximum glide ratio graph.

1.19 Additional information.

Nil.

1.20 Useful or effective investigation techniques.

Nil.

2. ANALYSIS.

It was a private flight between the Santa Edwiges Farm and SBPP, transporting the owner of the aircraft.

The pilot was qualified, had experience in the type of flight and, according to the data obtained, he had adequate rest time before the flight.

According to the calculations carried out, the fuel was sufficient to carry out the intended flight safely.

According to the data collected, the meteorological conditions were favorable for the visual flight, and it can be said that there was no contribution of this factor in the chain of events that led to the accident.

Also, according to reports, the pre-flight of the aircraft was started at a time that allowed adequate time for the completion of such checks. This procedure was performed by the pilot before the first take-off of the day and without consulting the manual.

Starting the engine and taxiing were carried out without any apparent problems. Shortly after the take-off, which took place around 1100 (UTC), with the aircraft at about 50 ft high, an observer saw black smoke being expelled from the engine exhaust. Then, there was a characteristic noise of abnormal engine operation.

The analyzes carried out on the engine by the investigators did not detect abnormalities in its adjustments, lubrication system, ignition system, internal components, nor the existence of leaks in bench tests.

However, a fracture was found in the fuel pump drive shaft. There was a pre-crack region on the fracture surfaces, followed by a torsional overload failure region, revealing a fragile fracture aspect, due to cleavage and intergranular fracture mechanisms.

It was concluded that the fracture of the fuel pump shaft initially occurred in a fragile manner, with the formation of a pre-crack of approximately 0.5 mm, followed by a ductile torsional fracture. Complementary examinations indicated that the broken shaft may have undergone a heat treatment that facilitated its fracture in service.

Fuel pump failure restricted engine power, resulting in loss of power.

According to the calculations performed, upon reaching 50 ft, when the first signs of engine failure were perceived, the aircraft had traveled around 565 meters of the area, leaving 635 meters ahead.

As predicted in the performance graph for the total landing distance, this remaining length would still be enough for the aircraft to perform a forward landing and a complete stop, which was predicted in the procedure Engine Failure on Takeoff (Low Altitude), as stated in Section 3, Emergency Procedures, of the POH.

The pilot chose to continue the take-off, gaining altitude to approximately 200 ft AGL.

At approximately 200 ft high, it is possible that the pilot performed a left reversal turn to position himself on final approach in the opposite direction of take-off.

Under turning conditions, the stall speed increases, as shown in Figure 14. When the pilot made a turn of approximately 60 degrees of bank with the flaps at 100% position, the stall speed approached the speed maintained at that instant by the aircraft.

The Cirrus SR20 aircraft POH established that the landing should be made in a field ahead, with a turn only to avoid obstacles. If the decision was to return to the runway, this maneuver should be performed carefully, so that the aircraft does not enter a stall condition.

The terrain in the extension of the area used for the take-off presented favorable conditions for the landing ahead, which would increase the chances of success during the emergency.

According to the calculations performed, with the aircraft at 200 ft AGL, it was possible that the aircraft could fly ahead at a distance on the ground approaching 0.35 NM (660 m). If it proceeded to the landing ahead, the pilot would have more time to choose the best location, which would allow him to concentrate on the procedures foreseen for the emergency.

Thus, it was inferred that, given the emergency situation, the pilot could have judged that the remaining power was sufficient to sustain the flight at low altitude, during the reversal turn to return to the runway, and this decision was possibly influenced by fear regarding the consequences that could arise from a forward landing.

Despite the critical situation, there was no CAPS activation, probably motivated by a low level of situational alert, given that the mentalization of the actions to be taken should be done before the take-off, as recommended by the manufacturer in the CAPS Guide.

3. CONCLUSIONS.

3.1 Facts.

a) the pilot had a valid CMA;

b) the pilot had valid MNTE and IFRA Ratings;

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

d) the aircraft had a valid CA;

e) the aircraft was within the weight and balance limits;

f) the airframe, engine and propeller logbook records were updated;

g) the weather conditions were favorable for the flight;

h) there was a fracture of the fuel pump shaft driven by the engine, which initially occurred in a fragile way, with the formation of a pre-crack of approximately 0.5 mm, followed by a ductile fracture by torsion;

i) the fuel pump failure prevented the aircraft engine from working as required, causing a loss of power;

j) the engine presented a characteristic sound of failure or malfunction, shortly after the aircraft left the ground at approximately 50 ft of height, with black smoke being expelled from the exhaust;

k) the operating procedures recommended in the basic piloting instruction manuals and common to aircraft similar to the SR20 recommended a forward landing in the presented situation;

l) according to reports, the aircraft entered a sharp left turn and lost altitude;

m) the extension of the take-off axis of the area used presented terrain with characteristics that allowed a landing ahead;

n) there was no CAPS activation;

o) the aircraft had substantial damage; and

p) the pilot and the passenger suffered fatal injuries.

3.2 Contributing factors.

- **Control skills – a contributor.**

Faced with a failure condition or engine malfunction, with the aircraft at low altitude, it was verified that the application of the commands to perform a turn with a large roll angle contributed to the increase in the stall speed, causing the aircraft to lose lift and colliding

with the ground.

- **Training – undetermined.**

The training and mentalization of using the CAPS could have induced the pilot to activate it, increasing the possibility of reducing the damage caused.

- **Manufacturing – undetermined.**

It is possible that the fuel pump shaft has undergone inadequate heat treatments, which have altered its mechanical properties.

- **Piloting judgment – a contributor.**

There was an inadequate assessment regarding the possibility of returning to the take-off area and the use of the CAPS after the engine failure, as guided by the manuals.

4. SAFETY RECOMMENDATION.

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

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

Recommendations issued at the publication of this report:

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

A-095/CENIPA/2017 - 01 **Issued on 07/08/2022**

Work with the Continental Motors representative in Brazil seeking to implement improvements in the reconditioning and quality control process, ensuring that all components installed in the engine maintain their original mechanical properties.

A-095/CENIPA/2017 - 02 **Issued on 07/08/2022**

Disseminate the lessons learned in this investigation to the operators of aircraft models SR20 and SR22 and to the Civil Aviation Instruction Centers certified to teach theoretical and practical courses on these aircraft models, in order to encourage the participation of pilots in recycling training and free courses offered by the manufacturer on the CAPS system.

5. CORRECTIVE OR PREVENTATIVE ACTION ALREADY TAKEN.

None.

On july 8th, 2022.