COMANDO DA AERONÁUTICA

CENTRO DE INVESTIGAÇÃO E PREVENÇÃO DE ACIDENTES AERONÁUTICOS

FINAL REPORT
A - 144/CENIPA/2019

OCCURRENCE:	**ACCIDENT**
AIRCRAFT:	**PT-LTJ**
MODEL:	**550**
DATE:	**14NOV2019**

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 14NOV2019 accident with the 550 aircraft model, registration PT-LTJ. The accident was classified as “[USOS] Undershoot / Overshoot – Undershoot”.

During the landing at the Barra Grande Aerodrome (SIRI), Maraú - BA, the aircraft made the touch before the threshold 11, bursting the main and auxiliary landing gears. In the sequence, the aircraft dragged along the runway and left it by the left side.

The aircraft was destroyed.

One crewmember and four passengers suffered fatal injuries and one crewmember and four passengers suffered serious injuries.

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

CONTENTS

GLOSSARY OF TECHNICAL TERMS AND ABBREVIATIONS

AGL	Above Ground Level
ANAC	Brazil's National Civil Aviation Agency
AP	Automatic Pilot
APP-IL	Ilhéus Approach Control
ATC	Air Traffic Control
CA	Airworthiness Certificate
CMA	Aeronautical Medical Certificate
COM	Maintenance Organization Certificate
CRM	Crew Resource Management
CVR	Crew Resource Management
ELT	Emergency Locator Transmitter
EGPWS	Enhanced Ground Proximity Warning System
GRAER-BA	Air Group of the Military Police of Bahia
IAM	Annual Maintenance Inspection
IFR	Instrument Flight Rules
IFRA	Instrument Flight Rating - Airplane
IMC	Instrument Meteorological Conditions
IOSA	Iata Operational Safety Audits
METAR	Aviation Routine Weather Report
NSCA	Aeronautics Command System Standard
NTSB	National Transportation Safety Board (USA)
PBZPA	Aerodrome Protection Zone Basic Plan
P/N	Part Number
PCM	Commercial Pilot License – Airplane
PF	Pilot Flying
PLA	Airline Pilot License – Airplane
PM	Pilot Monitoring
PMD	Maximum Take-Off Weight
PPR	Private Pilot License – Airplane
RBAC	Brazilian Civil Aviation Regulation
RBHA	Brazilian Aeronautical Certification Regulation
REDEMET	Aeronautics Command Meteorology Network
S/N	Serial Number
SACI	Integrated Civil Aviation Information System
SBIL	ICAO Location Designator - Jorge Amado Aerodrome, Ilhéus - BA
SBJD	ICAO Location Designator - Comandante Rolim Adolfo Andrade Aerodrome, Jundiaí - SP

SBSV	ICAO Location Designator - Deputado Luís Eduardo Magalhães Aerodrome, Salvador - BA
SIGWX	Significant Weather Chart
SIPAER	Aeronautical Accident Investigation and Prevention System
SIRI	ICAO Location Designator - Barra Grande Aerodrome, Maraú - BA
SOP	Standard Operational Procedures
SSXH	ICAO Location Designator - Sócrates Mariani Bittencourt Aerodrome, Brumado - BA
TAWS	Terrain Avoidance and Warning System
TLV	Life Time Limit
TMA-SP	São Paulo Terminal Control Area
TPP	Registration Category of Private Service - Aircraft
UTC	Universal Time Coordinated
VFR	Visual Flight Rules
VMC	Visual Meteorological Conditions

1. FACTUAL INFORMATION.

Aircraft	**Model:** 550 **Registration:** PT-LTJ **Manufacturer:** Cessna Aircraft	**Operator:** Private
Occurrence	**Date/time:** 14NOV2019 - 1717 UTC **Location:** Barra Grande Aerodrome (SIRI) **Lat.** 13°54'22"S **Long.** 038°56'24"W **Municipality – State:** Maraú – BA	**Type(s):** "[USOS] Undershoot / Overshoot" **Subtype(s):** Undershoot

1.1 History of the flight.

The aircraft took off from the Comandante Rolim Adolfo Amaro Aerodrome (SBJD), Jundiaí - SP, to the Barra Grande Aerodrome (SIRI), Maraú - BA, at about 1458 (UTC), in order to carry out a private flight, with two pilots and eight passengers on board.

Upon arriving at the destination Aerodrome, at 1717 (UTC), the aircraft made an undershoot landing on runway 11, causing the main and auxiliary landing gear to burst. The airplane moved along the runway, dragging the lower fuselage and the lower wing, leaving the runway by its left side, and stopping with the heading lagged, approximately, 210º in relation to the landing trajectory.

Afterwards, there was a fire that consumed most of the aircraft.

The aircraft was destroyed (Figure 1).

One crewmember and four passengers suffered fatal injuries and the other crewmember and four passengers suffered serious injuries.

Figure 1 - Placement of the wreckage.

1.2 Injuries to persons.

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

1.3 Damage to the aircraft.

The aircraft was destroyed.

1.4 Other damage.

A signpost, located approximately 70 meters from the threshold 11, had damage at the top (Figure 2).

Figure 2 - Signpost damage.

1.5 Personnel information.

1.5.1 Crew's flight experience.

Flight Hours		
	Pilot	Copilot
Total	8.000:00	350:00
Total in the last 30 days	11:40	25:50
Total in the last 24 hours	01:00	01:00
In this type of aircraft	2.500:00	25:50
In this type in the last 30 days	03:40	25:50
In this type in the last 24 hours	01:00	01:00

N.B.: The data relating to the flown hours were provided by the commander and the copilot's ones were obtained at the ANAC's SACI.

1.5.2 Personnel training.

The pilot took the PPR course at the Pernambuco's Aeroclub, in 1983.

The copilot took the PPR course at the Pará de Minas' Aeroclub, in 2016.

1.5.3 Category of licenses and validity of certificates.

The pilot had the PLA License and had valid C550 aircraft type Rating, and IFRA Rating.

The copilot had the PCM License and had valid C550 aircraft type Rating, and IFRA Rating.

1.5.4 Qualification and flight experience.

The commander was qualified and had experience in the type of flight, but the copilot, despite being qualified, had little experience in the type of aircraft.

1.5.5 Validity of medical certificate.

The pilots had valid CMAs.

1.6 Aircraft information.

The aircraft, serial number 550-0225, was manufactured by Cessna Aircraft, in 1981, and it was registered in the TPP category.

The aircraft had valid Airworthiness Certificate (CA).

Considering the date of the last IAM, the airframe and engines logbook records were updated.

However, considering that the logbook was consumed by the fire at the time of the accident, it was not possible to accurately survey the hours flown by the aircraft between the date of the last inspection and the date of the accident.

The last inspections of the aircraft, the “IAM/100h” type was carried out on 22MAY2019 by the maintenance organization *Construtora Nacional de Aviões* Ltd. - CONAL, in Sorocaba - SP.

On the IAM’s date, the aircraft had 6.978 hours and 10 minutes, and 6.769 total cycles.

According to the CA, the aircraft had a capacity for nine passengers, it was certified to operate with two pilots and had the internal seating configuration as shown in Figure 3.

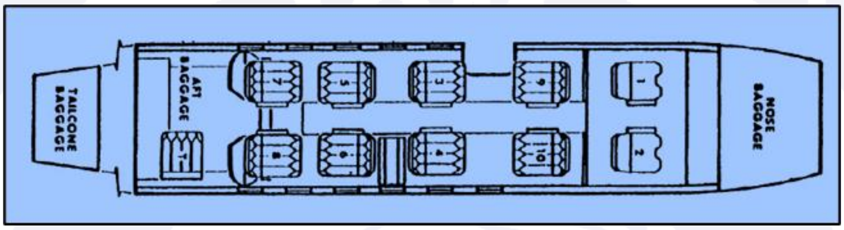

Figure 3 – Internal Configuration of the aircraft.
Sourse: Section 7-5 Crew and passenger seats and baggage.

Instruments and Equipment

- Terrain Avoidance and Warning System (TAWS).

The aircraft was equipped with a Garmin Avionics 430 and a GNS500, both with interface to the Avidyne EX500, with TAWS dedicated page and EGPWS.

The equipment received information from the GPS, from the uncorrected barometric pressure and external air temperature, in addition to having a database of runways, terrain and obstacles.

The issuance of alerts was based on the comparison between the trajectory and the information in the database of the terrain, obstacles and runways.

The equipment also had a protection mode, which issued the “Sink Rate” warning for cases of high rate of descent compared to altitude. For the most critical situations, the “Pull Up” warning was issued.

For cases in which critical conditions were detected in relation to terrain and obstacles ahead, at an approximate distance equivalent to one minute of flight, the equipment issued the warnings “Caution Terrain, Caution Terrain” or “Caution Obstacle”.

- Emergency Locator Transmitter (ELT)

The aircraft was equipped with an ELT, Martec Serpe, Artex C406-2 model, Part Number (P/N) S1821502-02, Serial Number (S/N) 2620552-0047, having been inspected at the last IAM, held on 22MAY2019, at the CONAL shop. The ELT battery was valid until February 2022, according to the record of 04DEC2015, contained in the logbook of the aircraft.

1.7 Meteorological information.

The Barra Grande Aerodrome (SIRI) did not have a meteorological service.

The Meteorological Opinion issued by the Integrated Aeronautical Meteorology Center described the meteorological conditions observed in the accident area, highlighted in the map below with a green square.

The satellite image highlighted at 1700 UTC, on 14NOV2019, made available by the REDEMET, shows that, over the accident region, there was no cloudiness with vertical development and that the cloudiness associated with the region of the study corresponded to *cumulus humilis*, that is, cloudiness with little vertical development and characteristic of good weather (Figure 4).

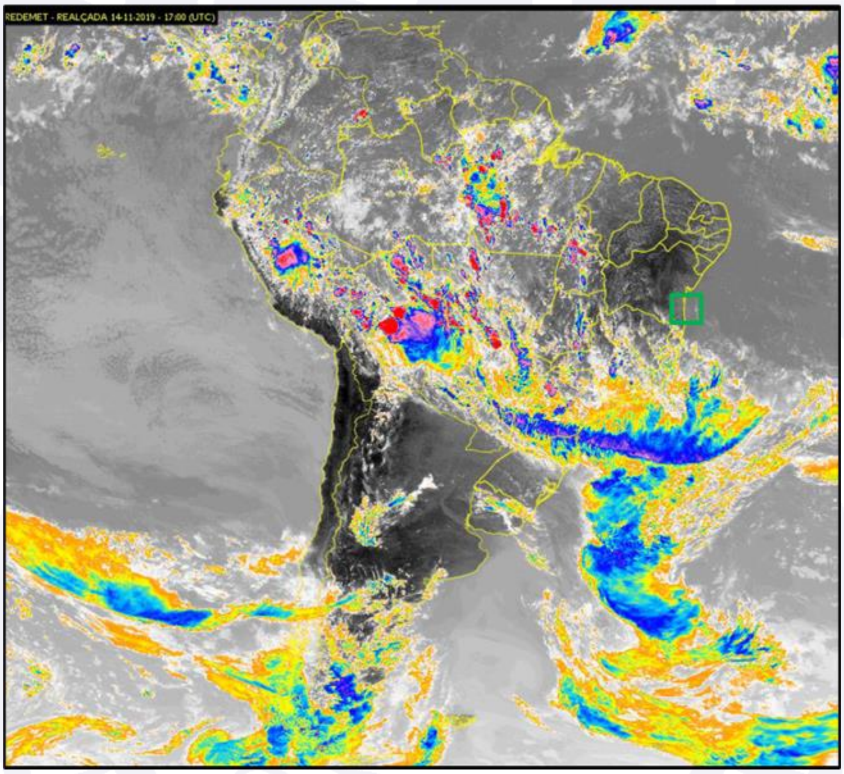

Figure 4 - Enhanced satellite image, from 14NOV2019, at 1700 UTC.

Based on the position of the Aerodrome windsock, it was estimated that the wind speed at the time of the accident was 06kt and the direction was 070º (Figure 5).

Figure 5 - Windsock indicating the wind condition at the time of the accident.

In view of the observed and predicted conditions, it was found that there was no area of instability and adverse conditions that would have compromised air operations in the accident region.

1.8 Aids to navigation.

Nil.

1.9 Communications.

According to the transcripts of the recordings, it was found that the pilots maintained full radio contact with the air traffic control agencies and that there was no technical abnormality in the communication equipment during the flight.

Communications between the PT-LTJ and the air traffic control agencies were carried out in a coordinated and clear manner, without anything significant to be reported.

During the descent, the PT-LTJ started communicating with the Ilhéus Approach Control (APP-IL), informing that it had crossed FL 160.

The APP-IL reported that the wind in SBIL was 100º (direction), 11kt (intensity) and the altimeter setting was 1,012hPa. It requested that the aircraft descend to FL 080 and report on reaching that level or for modifying flight rules (IFR to VFR). It also requested the estimated time for landing.

The PT-LTJ informed that the landing would occur in the next eight minutes, requesting, immediately after, the "cancellation" of the IFR flight rules.

Upon being informed that the PT-LTJ was crossing the FL 100, the APP-IL reported that the flight plan was modified and instructed the aircraft to descend to the traffic altitude, confirming that the altimeter setting was 1,012hPa.

Right after the message was collated by the PT-LTJ, the APP-IL requested that the aircraft reported when passing 4.000ft, adding that in case of failure in communications, after crossing that altitude, make a call on the free frequency 123.45MHz and that the pilot to be attentive to the aircraft (previously informed) that would take off from the destination Aerodrome (SIRI).

The PT-LTJ reported that it had coordinated with the aircraft on the ground.

The APP-IL requested that the PT-LTJ continued on the free frequency (123.45MHz) after being informed that the aforementioned aircraft had crossed four thousand feet.

The PT-LTJ ended the communication confirming that it would remain listening to the free frequency.

1.10 Aerodrome information.

The Barra Grande Aerodrome (SIRI) was private, operated under the rules of visual flight (VFR), during daytime.

The runway was located at sea level, was made of concrete, with 11/29 thresholds, was 1,200 meters long and 23 meters wide. Threshold 11 was normally the most used for landings.

The wind direction indicator (windsock) was in a visible place, close to the threshold 11.

The Aerodrome was not equipped with a visual approach ramp indicator system. The RBAC 154, dated 12SEPT2019, which dealt with Aerodrome Design, established that the visual ramp and approach indicator systems would have their mandatory application only for public Aerodromes.

At the time of the accident, the Aerodrome was open for air traffic and the runway was unobstructed and dry.

Regarding the SIRI infrastructure, operational information was collected which showed that on 20MAY2020, the Official Gazette of the Union published ICA Ordinance No. 154 / SAGA, of 21APR2020, which dealt with the PBZPA for the Aerodrome of Barra Grande, in the respective Aerodromes Information Sheet its new characteristics, among which, the length of 1,400m, the width of 30m, the length of the runway strip of 1,520.01m and the width of the runway strip of 80m stood out, in addition, also informed about the possibility of day and night operations.

The use of the criteria established in RBAC 154 to be adopted in the projects for private Aerodromes was the responsibility of the interested party or its technical responsible, since its application was not mandatory. It should be noted that there were no current project requirements for private Aerodromes, since RBAC 154 was mandatorily applied to public Aerodromes.

The ANAC Resolution No. 158, of 13JUL2010, which dealt with the prior authorization for the construction of Aerodromes and their registration with the ANAC, stated that:

> ...
>
> Art 12. The registration, or its update, will take place upon request of the interested party.
>
> §1st It constitutes updating of the enrolment in the registry:
>
> I - Change of data or information on physical or operational characteristics previously registered;
>
> II - Exclusion, with cancellation of the effects of the administrative act that authorized the registration;
>
> ...
>
> §7th The certified Aerodrome operators will request changes to the physical or operational characteristics through the procedure provided in RBAC 139, being exempted from carrying out the procedure prevised in Paragraph 1, item I, of this article. (Included by Resolution No. 484, of 26JUL2018).
>
> Available at: https://www.anac.gov.br/assuntos/setor-regulado/aerodromos/ cadastro-de-aerodromos /informacoes-adicionais (access on 08SEPT2020).

About Technical Drawings (Plans and Projects), in Private Aerodromes, it was stated in a report on the ANAC website, of 12MAR2016:

> Technical drawings are not required to instruct the Aerodrome construction authorization process. The ANAC Resolution No. 158, of 13JUL2010, establishes its obligation only for the cases provided in paragraph 3 of art. 12, which occurs only when registering the Aerodrome. Thus, for private Aerodromes without scheduled flights, this Agency does not analyze the infrastructure projects, being the responsibility of the engineer in charge for the project and the owner of the Aerodrome.
>
> It should be noted that there are no current project requirements for private Aerodromes, since the RBAC 154 applies, necessarily, only to public Aerodromes. The use of the criteria of this Regulation in private Aerodrome projects is the responsibility of the interested party or his / her technical responsible, since its application, reinforcing, is not mandatory.
>
> Available at: https://www.anac.gov.br/assuntos/setor- regulado/aerodromos/ cadastro-de-aerodromos/informacoes-adicionais/drawings-technicians-plans-and-projects (access 08SEPT2020).

The private Aerodrome SIRI had its registration renewed at the ANAC's Aerodromes registration through the Ordinance No. 3,610/SIA, on 07DEC2020. Since then, the runway dimensions have been changed from 1,200m X 23m to 1,400m X 30m and the type of operation has been changed from daytime to daytime/nighttime, as can be verified by the ANAC process No. 00065.040672 / 2020-55 on the ANAC's website.

1.11 Flight recorders.

According to section 91.609, of the RBHA 91, which dealt with the General Operating Requirements for Civil Aircraft, the installation of Cockpit Voice Recorder (CVR) was required for multi-engine aircraft, with turbine engines, which had an approved configuration for passengers with six or more seats and for which two pilots were required by the approval requirements or by an operational rule.

RBHA 91, in force at the time, which provided for General Operating Requirements for Civil Aircraft, established:

> 91,609 Cabin flight and voice data recorders
>
> ...
>
> [(c)] No person may operate a civil aircraft registered in Brazil, multi-engine, with turbine engines, having a maximum configuration for passengers, excluding any pilot seat, with 10 or more seats and which was built after 11OCT1991, unless the aircraft is equipped with one or more approved flight data recorders, which use digital techniques to record and retain the recording, capable of recording the data specified in Appendix E (in the case of airplanes) or in the Appendix F of this regulation (in the case of helicopters), within the specified ranges, accuracy and recording intervals, and keep them for not less than 8 hours of aircraft operation.
>
> ...
>
> [(e)] Unless otherwise authorized by the DAC, after 31DEC2001, no person may operate a civil aircraft registered in Brazil, multi-engine, with turbine engines, having a maximum configuration for passengers with 6 or more seats and for which 2 pilots are required for approval requirements or an operational rule, unless it is equipped with an approved voice recorder in the cockpit that:
>
> (1) it is installed in accordance with the RBHA 23 (paragraphs 23.1457 (a) (1) and (2), (b), (c), (d), (e), (f) and (g)), with the RBHA 25 (paragraphs 25.1457 (a) (1) and (2), (b), (c), (d), (e), (f) and (g)), with the RBHA 27 (paragraphs 27.1457 (a) (1) and (2), (b), (c), (d), (e), (f) and (g)), or with the RBHA 29 (paragraphs 29.1457 (a) (1) and (2), (b), (c), (d), (e), (f) and (g)), as applicable; and
>
> (2) it is operated continuously from the moment the aircraft is energized before the flight until the moment the aircraft is de-energized after the flight, as provided in the checklist.

Therefore, installing the CVR on the crashed aircraft was mandatory, but the flight data recorders were not.

The aircraft was equipped with a CVR, model AR30B, manufactured by Allied Signal, (Figure 6) and allowed a recording time of 30 minutes.

Figure 6 - Cockpit Voice Recorder that equipped the aircraft.

Its battery was installed in September 2014, with a TLV of six years.

In the aircraft's documentation there was no record of CVR malfunction.

During the investigation at the accident site, the CVR was collected from the wreckage and sent to the CENIPA's LABDATA, to read the communications established by the pilots in the aircraft's cockpit.

However, after downloading the data, it was found that the existing audio did not match the one of the accident flight.

It was not possible to determine whether the equipment was inoperative at the time of the takeoff.

1.12 Wreckage and impact information.

In the final approach for SIRI, the aircraft touched a signpost, located before the runway and hit a ravine 21 meters ahead (Figures 7 and 8).

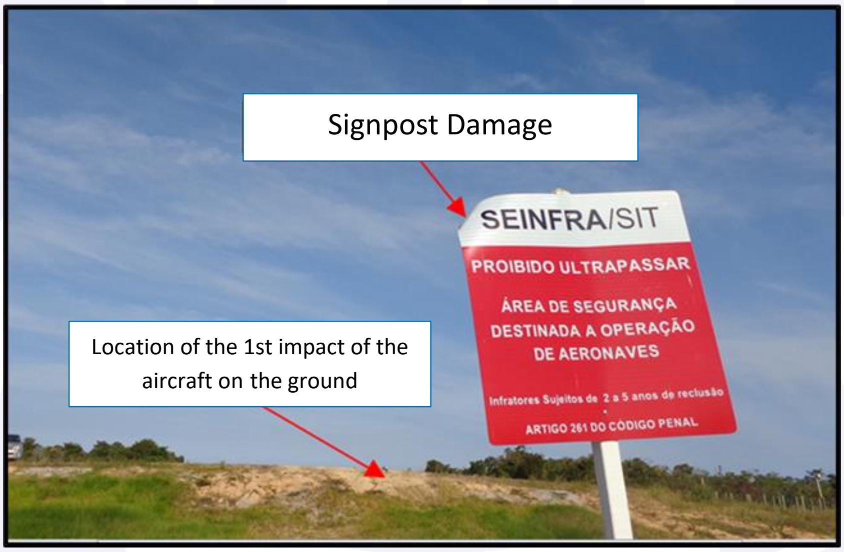

Figure 7 - Damaged signpost and location of the aircraft's first impact on the ground.

Figure 8 - Location of the first impact on the ground.

As a result of the impact with the ravine, there was the breakage of the main and auxiliary landing gears, as well as their respective doors and actuating cylinders (Figures 9, 10 and 11).

Figure 9 - Right main landing gear with the actuator cylinder.

Figure 10 - Left landing gear with the actuator cylinder.

With the breakage of the auxiliary landing gear, the wheel was thrown to the right, stopping outside the Aerodrome isolation fence, approximately 250 meters away (Figure 11).

Figure 11 - Auxiliary landing gear wheel.

After the first impact with the terrain, the aircraft went up and surpassed the ravine. When crossing the threshold 11, the pilot commanded the touch of the aircraft on the runway, which occurred 47 meters ahead (Figures 12 and 13).

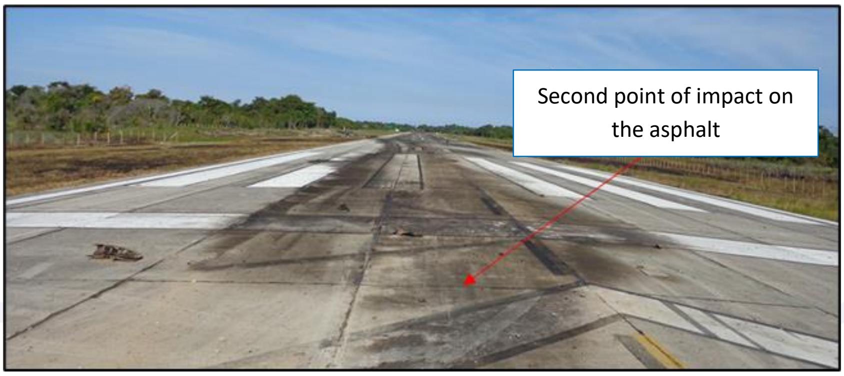

Figure 12 - Second point of impact.

The aircraft dragged for 147 meters, catching fire. During this displacement, he left a trail of fire, turned left, leaving the runway by its left side (Figure 13), stopping with the heading lagged approximately 210º from the landing path (Figure 14).

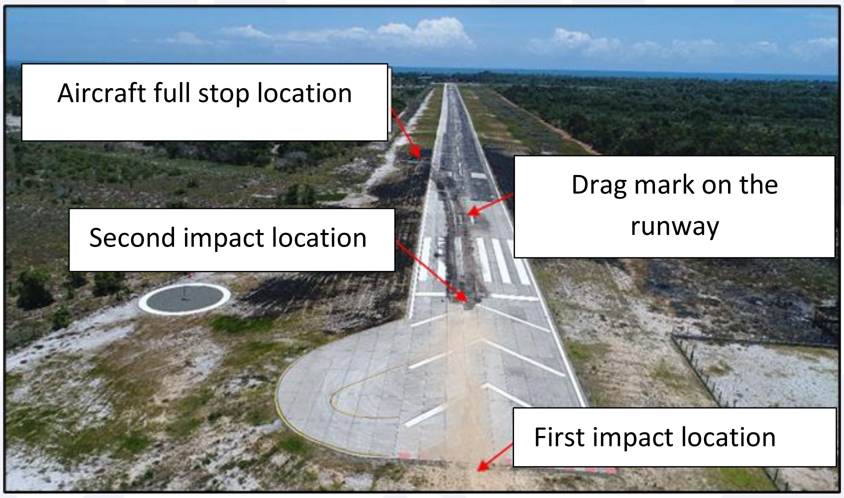

Figure 13 - Marks on the runway indicating the impact and drag locations of the aircraft.

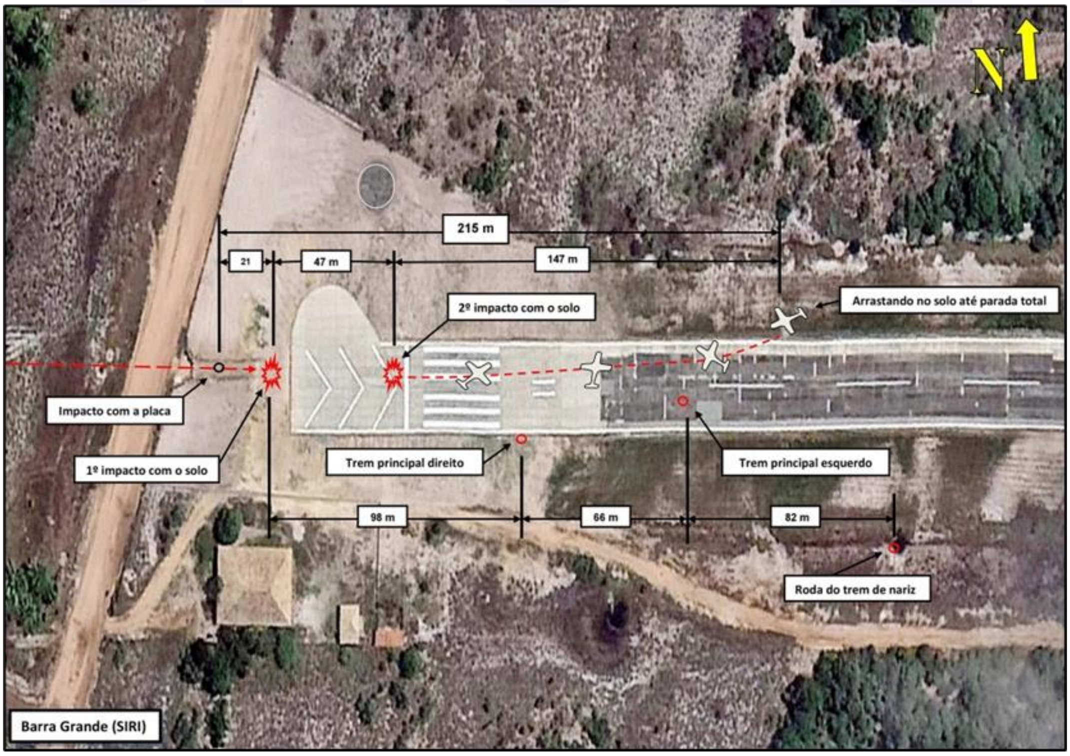

Figure 14 - Sketch of the accident.

1.13 Medical and pathological information.

1.13.1 Medical aspects.

He was an experienced professional, with about thirty-six years of training as a pilot, of which twenty-five he worked as an Airline Pilot (PLA).

The commander was 66 years old. His last health inspection was carried out in a medical clinic accredited by the ANAC and was valid until 17MAY2020.

According to the result of the aforementioned inspection, the commander was able to perform aerial activity, with observation for the use of corrective lenses.

He regularly used some medications and a vitamin complex.

No toxicological tests were carried out after the accident.

The analysis of the records that subsidized the last two health inspections indicated a progressive bilateral hearing loss, having been observed, in the interval of six months, loss in more than one frequency in both ears, including a borderline loss of 35dB in the 2,000hz frequency (500hz / 2,000hz - band considered critical for aviation, in which the maximum loss of 35dB is allowed, according to section 67.101 of the RBHA 67).

The RBHA 67, which dealt with requirements for the granting of aeronautical medical certificates, registration and accreditation of doctors, accreditation of clinics and agreement with public entities, established:

> 67,101 Hearing requirements
>
> (a) Except as set out in paragraph (b) of this section, the candidate submitted to a pure tone audiometer test must not have a hearing impairment, in each ear separately, greater than 35dB in any of the three frequencies of 500, 1,000 and 2,000Hz, nor greater than 50dB at the 3,000Hz frequency. This exam must be carried out on all candidates for obtaining a CMA, at least once every 5 years on revalidation applicants under 40 years old, and at least once every 2 years on revalidation candidates aged 40 or older.

In the records corresponding to the health inspections analyzed, there was no recommendation on medical follow-up and monitoring in relation to the commander's hearing loss.

During the interview, the commander classified his work routine as calm, stating that he had no employment relationship with any company, and that he used to fly only to a few friends or aviation shops, with low weekly frequency.

On the eve of the accident, he performed only one maintenance flight of the aircraft and claimed to have slept satisfactorily and to have eaten light meals, both at dinner the night before and in the morning of the occurrence’s day.

He reported that he did not know the Barra Grande runway and that he analyzed the conditions of the Aerodrome, on the eve of the accident, through the google maps app. Upon flying over it, moments before the accident, he stated that he had some strangeness in relation to the geography of the terrain, mainly due to the existence of dunes in the vicinity of the Aerodrome, as well as due to the double coloring of the runway, sometimes asphalt, sometimes concrete.

1.13.2 Ergonomic information.

Nil.

1.13.3 Psychological aspects.

According to the information collected, before the flight proposal with the PT-LTJ aircraft, the commander had worked for seventeen years in a company where he performed demonstration flights.

As reported by people from his professional life, the commander was described as a quiet person, easy to live with, dedicated and professionally accomplished.

Also, according to the commander's own statement, there was no employment relationship between him and the aircraft owner.

Regarding the flight that originated the occurrence, he stated that he was consulted by a friend, who was also a pilot, regarding the possibility of doing it.

He reported that, on the day of the occurrence, he was calm and confident, as he had experience on the aircraft.

According to the data obtained, the copilot also had no employment relationship with the aircraft owner.

According to reports, the copilot was disciplined, discerning and skilled. It was reported to the commander that the copilot was considered a professional of initiative and leadership.

The crew had previously flown another flight, about thirty days before the accident, with an approximate duration of two hours. According to the commander, at that time, it was not possible to adequately assess the performance of that crewmember, as the flight required a high workload, since it was a short flight, at night, with a change of rules from IFR to VFR, in the corridors of the TMA-SP.

According to the information collected, the copilot was called for the flight after agreements between the commander and the owner of the aircraft, who carried out the negotiations in relation to the flight.

According to the commander's report, the flight had gone smoothly. However, he reported that during the final approach, the copilot had not adequately verbalized the callouts, especially the speeds.

As the commander did not have a greater knowledge about the professional part of the copilot, as the two had only performed one flight together, he started to check the checklist procedures performed by the copilot, making sure that those tasks were correctly performed.

The commander remembered that the last item observed was related to the landing gear, when he confirmed that he had the control lever in the “lowered” position and the three green lights on.

Then, when looking ahead and realizing that the aircraft was far below ideal and very close to the threshold 11, he applied maximum power to the engines and pitched up, in an attempt to correct the aircraft ramp.

Despite this attempt of correction, the aircraft crashed into an existing gully at the runway's threshold when the engines started accelerating.

1.14 Fire.

The fire started immediately after the contact of the aircraft with the runway.

The combustion material was the aircraft fuel and the ignition source originated because of the strong friction with the terrain.

After the impact with the terrain, the tanks of the wings broke, making a trail of fuel on the runway. The fire followed the fuel trail until reaching the aircraft on its stopping point. (Figure 15).

Figure 15 – Accident site seen from a distance.

There was no counter-fire service at the Aerodrome, nor in the vicinity of Maraú. The nearest support structures were the Military Fire Brigade, based in the city of Ilhéus, about 160km away.

An Aerodrome administration official, and people who were nearby, using five 12kg ABC type fire extinguishers, tried to fight the fire at the Aerodrome.

Due to the rapid spread of fire, the occupants of the aircraft suffered burn injuries, ranging from severe to fatal.

The situation was aggravated by the fact that the aircraft was fueled with about 1,800lb (1,020 liters) of fuel at the time of the accident.

The fire spread through the undergrowth surrounding the aircraft wreckage.

The aircraft was destroyed by fire (Figure 16).

Figure 16 - Destroyed aircraft and extension of the flames.

The RBAC 153, which dealt with Aerodromes, operation, maintenance and emergency response, established that the requirements prevised in this regulation were mandatory only by Aerodrome operators that operated in a Brazilian public civil Aerodrome, shared or not.

1.15 Survival aspects.

One of the passengers was unable to leave the aircraft that was on fire and died on the spot.

After the aircraft was abandoned, the survivors were transported in private cars to a health center in the municipality of Maraú, where they remained for approximately two hours.

With the arrival of the GRAER-BA aircraft, the victims returned to the Aerodrome (SIRI) in the same private cars, where they were removed to the General Hospital of the State and to the Suburb Hospital, located in Salvador.

1.16 Tests and research.

Nil.

1.17 Organizational and management information.

Nil.

1.18 Operational information.

The flight originated in SBJD, which had a 1,400m long and 30m wide paved runway, being considered as the aircraft's base of operations.

According to the commander involved in the accident, the flight aimed at demonstrating the aircraft for sale, since the respective owner had purchased another turbo jet aircraft.

There was no employment relationship between the pilots and the aircraft owner/operator.

During the preparations for the flight, in the morning of 14NOV2019, the day of the accident, the aircraft was refueled with 4,178lb (1,896kg) of fuel (JET A1), totaling 4,700lb (2,132kg) of aviation kerosene in the tanks.

The presented plan foresaw the departure from SBJD, at 1430 (UTC), with four hours of autonomy, under the rules of visual flight (VFR), until the blocking of BGC (VOR of Bragança Paulista), in TMA - SP.

From BGC, it would climb to flight level 330 (FL 330), under the instrument flight rules (IFR), remaining at that level until the fix MUMA. From that point, the aircraft would begin descending to level 075 (FL 075), under visual flight rules, flying straight to Maraú (SIRI).

Before the takeoff, the pilots learned about the weather conditions in the region of the destination and alternative Aerodromes, as well as the route.

On the route, the weather was good and the destination Aerodrome was in visual condition.

The Aerodrome operator was authorized to operate the PT-LTJ.

The flight en route went smoothly. The equipment and systems, including the powerplant, were operational, allowing the aircraft to perform properly in all phases of the flight.

The flight time was estimated at two hours and thirty minutes, with the Deputado Luís Eduardo Magalhães Aerodrome (SBSV), Salvador - BA, as an alternative.

The aircraft commander reported that he had never operated at the Barra Grande Aerodrome, having used the Google Maps application to conduct the recognition of the Aerodrome during preparations for the flight.

The commander of the aircraft exercised the function of Pilot Flying (PF) and the copilot Pilot Monitoring (PM).

As reported, the TAWS was “silenced” in the final approach by the PF, since, although the data bank for the Avidyne and Garmin 400 equipment installed on the aircraft was updated, they did not contain information related to the Barra Grande Aerodrome.

During the descent, the PT-LTJ started communicating with the APP-IL, informing that it had crossed the FL 160.

The APP-IL requested that the aircraft descend to FL 080.

Upon being informed that the PT-LTJ was crossing the FL 100, the APP-IL reported that the flight plan was modified and instructed the aircraft to descend to traffic altitude.

According to the commander, prior to the descent check, the procedures that should be adopted during the approach and landing were commented, according to the CRM techniques, including the conditions of the runway and the aspects of the go-around procedure, such as: power, landing gear configurations, flaps and speed breaks.

The aircraft crossed the Aerodrome at traffic altitude, 1,500ft high.

The autopilot (AP) was disengaged at the intersection of the aerodrome, when the aircraft was developing approximately 170 KIAS.

At about 160 KIAS, it entered the leg of the wind, which extended to a distance of approximately 4.5 NM beyond the threshold, with reduced speed to 155/145KIAS.

The commander reported that on the leg of the wind, he took two photographs of the runway and of the Aerodrome with his cell phone.

Before the base curve, the PM was asked to lower the flaps to 15º and, when starting it, the PF asked for the landing gear to be lowered, which was followed by the confirmation of the three green lights on.

Finishing the base curve and starting the final straight, the aircraft was, approximately, with 145 KIAS.

When entering the long final straight, at around 1,200ft in height, the PM was asked to lower the flaps to 40º (full) and the check before landing checklist, with an engine power regime of 55% N1 and speed of 136 KIAS, with the aircraft aligned with the runway at about 3.5 NM from the threshold 11 of the Aerodrome (SIRI).

Upon crossing 1,000ft AGL, according to the commander's initial report and, with an approximate speed of 126 KIAS, the PF commanded the power levers to the Idle position (minimum power), as he realized that the aircraft was above the ideal ramp (Figure 17).

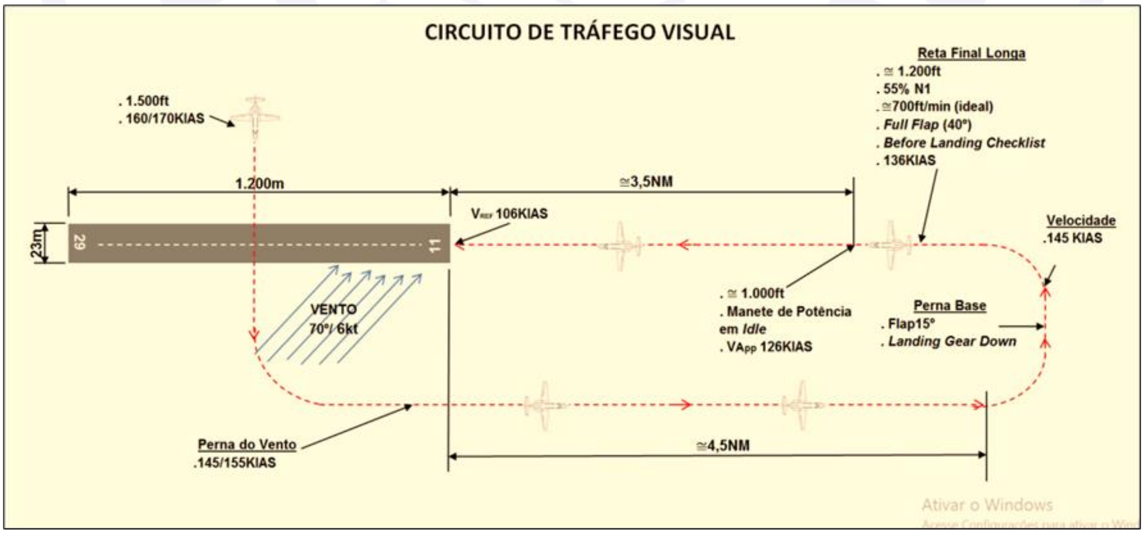

Figure 17 - Profile of the traffic circuit according to the commander's initial declaration.

On a second moment, during the investigation, the pilot declared that the throttles were reduced to Idle and returned to 50% of N1 on the stabilized ramp during the final approach.

The commander also reported that, in the “final approach”, less than 1/4 of a mile from the threshold, he felt that the aircraft was losing support, without aural alarm from the stall, and that this perception was accompanied by the following verbalization by the PM: “One hundred and six knots! Go-around”.

According to the commander, on that flight, the PM verbalized the callouts in a low voice, notably in the visual traffic, to the point of being asked to repeat some checklist items, as well as verbalizing the speeds with a higher voice intensity, since the pilots were without the head phones.

In view of this, he initiated the verification of the execution of the checklist procedures under the responsibility of the PM, turning his attention to the interior of the cockpit, concomitantly with the piloting of the aircraft.

The last item observed was the landing gear, and it was verified, through the three green lights on, that it was in the down and locked position.

Then, the PF returned to look ahead, being frightened by the fact that the aircraft was far below the ideal ramp and very close to the threshold 11.

Immediately, he applied maximum power to the engines and pitched up the aircraft, despite this, due to the delay in the acceleration of the engines, the PF did not notice the reaction (acceleration) of the aircraft. Soon after, it collided with a signpost and, then, in the ravine near the threshold 11, with the collapse of the main and auxiliary landing gears.

Then, the PF reduced the power of the engines to Idle and commanded the speed break on, forcing the aircraft to touch the runway.

The decision to interrupt the go-around procedure came after the PF's distrust of the severity of the aircraft's impact against the ravine, and of the possible damage caused to the landing gear.

The profile of the final approach and the attempted go-around procedure, based on the commander's report, is described in Figure 18.

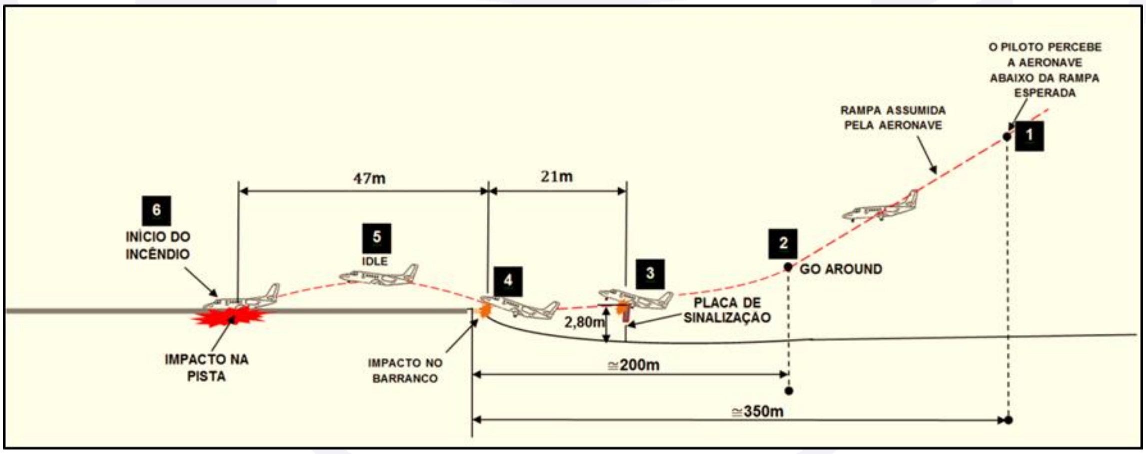

Figure 18 - Profile of the final approach and attempted go-around procedure, based on the commander's report.

Regarding the interaction with the copilot, the commander commented that he had already experienced similar situations of little rapport with other copilots, due to the fact that they had not had the opportunity to make other flights together. He added that, on that flight, due to the little knowledge he had of the copilot, he had defined that in case one of them put the aircraft's operation at risk, the other would assume the role of Pilot Flying.

During the investigation, it was found that, after the second impact on the runway, the aircraft dragged itself on the asphalt for 147 meters, until the moment when the PF claimed to have commanded a ground loop on the left with the pedals. After a 180º turn, the aircraft stopped at the side of the runway and was engulfed in fire.

There was no record of triggering the ELT at the time of the accident.

As for weight limitations, the aircraft's operating manual, in Section 1, Descriptions and Specifications, page 1- 6A, Operating Limitations, stated:

Weight MODEL 550

Maximum Ramp Weight ………….. 13,500lb (6.123kg)

Maximum Takeoff Weight ……….....13,300lb (6.033kg)

Maximum Landing Weight 12,700lb (5.760kg)

Maximum Zero Fuel Weight 9,500lb (4.310kg)

According to the aircraft's Weight and Balance Sheet, its Basic Weight was 3,737kg (8,238lb), the Maximum Takeoff Weight (PMD) of 6,033kg (13,300lb) and the Maximum Landing Weight of 5,760kg (12,700lb).

For the purpose of calculating the take-off weight, the data in Figure 19 were considered, whose passenger weights were presented by the aircraft commander and those of the pilots were obtained through their respective expert health examination forms.

WEIGHT TABLE IN POUNDS	
BASIC WEIGHT OF THE AIRCRAFT	8.238
FUEL (4.700lb)	4.700
CREWMEMBER I	205
CREWMEMBER II	141
FEMALE PAX I	110
FEMALE PAX II	110
FEMALE PAX III	110
CHILD PAX	66
MALE PAX III	143
MALE PAX IV	136
MALE PAX V	141
MALE PAX VI	128
LUGGAGE	143
TAKEOFF WEIGHT	14.371

Figure 19 - Takeoff weight.

As for the weight limitations of civil aircraft, transport category, section 91.605, of the RBHA 91, provided that:

> ...
>
> (b) No person may operate a transport category airplane with turbine engines, approved in their country of origin after September 30, 1958, contrary to the provisions of its approved Flight Manual. In addition, no person can take off with this airplane unless:
>
> (1) the take-off weight does not exceed the take-off weight provided for in the Flight Manual for the altitude of the departure Aerodrome and for the ambient temperature existing at the time of the take-off.

The fuel consumed on the flight, which lasted two hours and twenty minutes, was approximately 2,900lb. For this purpose, the aircraft's performance graphics were considered.

Thus, the approximate weight of the aircraft was obtained at the time of the accident (Figure 20).

WEIGHT TABLE IN POUNDS	
TAKEOFF WEIGHT	14.371
CONSUMED FUEL WEIGHT	2.900
LANDING WEIGHT	11.471

Figure 20 – Estimated Landing Weight.

Considering, conservatively, the landing weight of 11,500 lb and using the data in Figure 21, with a temperature of 30º, the landing distance of approximately 2,210ft or 673m was obtained.

NORMAL PROCEDURES — MODEL 550/551

LANDING DISTANCE - FEET — FLAPS - FULL

ACTUAL DISTANCE

PA	SEA LEVEL					
°C	WEIGHT - POUNDS					
	8500	9500	10,500	11,000	11,500	12,000
45	2200	2140	2160	2220	2270	2320
40	2180	2120	2150	2200	2250	2300
35	2170	2110	2130	2180	2230	2280
30	2150	2090	2110	2160	2210	2270
25	2140	2070	2100	2150	2200	2250
20	2120	2060	2080	2130	2180	2230
15	2100	2040	2060	2110	2160	2210
10	2090	2030	2040	2090	2140	2190
5	2070	2010	2030	2070	2120	2170
0	2050	1990	2010	2060	2100	2150
-5	2040	1980	1990	2040	2080	2130
-10	2020	1960	1980	2020	2060	2110
-15	2000	1940	1960	2000	2050	2090
-20	1990	1930	1940	1980	2030	2070
-25	1970	1910	1930	1970	2010	2050

Figure 21 - Landing distance chart.
Source: Checklist 550, Normal Procedures, page N18.

Also according to the aircraft commander, during the flight, the following speeds were calculated: VAPP - 116 KIAS and VREF - 106 KIAS.

The onboard GPS showed that the wind at the destination aerodrome was 90 degrees (direction), varying between 08kt and 10kt (intensity).

Based on the table in Checklist 550, Normal Procedures, page N18, which dealt with the VREF, for landings on runways at sea level and at altitudes of 1,000ft and 2,000ft, the speed of 104 KIAS was found, Figure 22.

VREF - (GEAR DOWN AND FLAPS - LAND)

	WEIGHT - POUNDS						
	13,300	13,000	12,500	12,000	11,500	11,000	10,500
SPEED - KIAS	111	110	108	106	104	101	99

	WEIGHT - POUNDS				
	10,000	9500	9000	8,500	8,000
SPEED - KIAS	97	95	92	90	87

Figure 22 - VREF speed chart.
Source: Checklist 550, Normal Procedures, page N18.

The aircraft Operations Manual in Section 4 - item 15, page 23, Operating Information, recommended the following:

> 15. Air speep - VREF.
>
> Consistently comfortable and safe landings are best achieved from a stabilized approach. The point at which the airplane should be stabilized with airspeed at VREF to VREF +10 KIAS, full flaps, and the desired descent rate is normally coincident with commencing the final descent to landing. Under instrument conditions, this usually occurs at the final approach fix inbound. During visual approaches, this would

be a point approximately equal to a turn onto base leg, adjusted for the altitude difference between the traffic pattern and field elevation.

After passing the instrument approach fix outbound or nearing the airport traffic area, airspeed should be reduced below 202 KIAS and the flaps extended to the APPR (15°) position. Approaching the final instrument fix inbound (one dot from glideslope intercept on an ILS), or a downwind abeam position, extend the landing gear below 176 KIAS. At the point where final descent to landing is begun, extend FULL flaps, establish the desired vertical rate, and adjust power to maintain VREF to VREF+10 KIAS indicated airspeed.

Power management during the approach/landing phase is relatively easy in the Citation II because an N1 setting in the 60-65% range will normally result in desired indicated airspeeds for the various configurations. Depending on air traffic control requirements, thrust necessary for the entire approach can often be set during descent keeping in mind that fan (N1) RPM will decrease slightly for a fixed throttle setting with a decrease in altitude or indicated airspeed.

Using a sea level airport with zero wind at a typical landing weight (10,000 pounds), a throttle setting that results in about 60% N1 in close will give up proximate level flight indicated airspeeds of 160 knots clean and 140 with flaps APPR. Gear extended, flaps FULL and commencing an average descent (500 FPM) will result in approximately VREF airspeed. Higher field elevations, landing gross weights and/or headwind component will require a greater power setting.

For maneuvering prior to final approach, minimum airspeeds of VREF +30, VREF +20 and VREF+10 should be maintained clean, flaps APPR and flaps LAND respectively to provide an adequate margin above stall.

The commander reported that, in the last few years, he had carried out training with skids at Flight Safety (2016), SIMCOM Aviation Training (2018) and CAE (2019), which employed the same philosophy of Flight Safety and CRM techniques, which contributed to improving the performance of the pilot in command. In the last two training sessions he had performed the training stages at American airports, with at least three different copilots, always using the English language.

1.19 Additional information.

- Aircraft

The aircraft was required to have a TAWS / EGPWS system installed, in accordance with section 91.223 of the RBHA 91, in force at the time of the accident, which established:

(a) Airplanes manufactured after December 31, 2003. Except as provided in paragraph (d) of this section, no person may operate an airplane with turbine engines registered in Brazil with a configuration of six or more seats for passengers, excluding any seats for pilot, unless the airplane is equipped with an approved EGPWS that meets the requirements for the OTP Class B (TSO) - C151 equipment (device equipped with the ground detection function in front of the plane).

(b) [Airplanes manufactured on or before January 1, 2004. Except as provided in paragraph (d) of this section, no person may operate an airplane with turbine engines registered in Brazil with a configuration of six or more seats for passengers, excluding any pilot seat, after December 31, 2007, unless the airplane is equipped with an approved EGPWS that meets the requirements for the OTP Class B (TSO) - C151 equipment (device equipped with the ground detection function in front of the plane).]

(c) Approved Flight Manual. The Approved Flight Manual (AFM) must contain appropriate procedures for:

(1) the use of the ground proximity perception and alarm system; and

(2) appropriate reaction of the flight crew in response to visual and audible alerts from the ground proximity perception and alarm system.

Still in relation to the TAWS/EGPWS, FAA-H-8083 (Advanced Avionics Handbook), pages 5-8 and 5-9, established the following situations of potential danger and their aural alerts:

> Terrain Awareness and Warning Systems.
>
> A terrain awareness and warning system (TAWS) offers you all of the features of a terrain display along with a sophisticated warning system that alerts you to potential threats posed by surrounding terrain.
>
> A terrain awareness and warning system uses the aircraft's GPS navigation signal and altimetry systems to compare the position and trajectory of the aircraft against a more detailed terrain and obstacle database. This database attempts to detail every obstruction that could pose a threat to an aircraft in flight.
>
> TAWS A and TAWS B
>
> There are presently two classes of certified terrain awareness and warning systems that differ in the capabilities they provide to the pilot: TAWS A and TAWS B.
>
> A TAWS A system provides indications for the following potentially hazardous situations:
>
> 1. Excessive rate of descent
> 2. Excessive closure rate to terrain
> 3. Altitude loss after takeoff
> 4. Negative climb rate
> 5. Flight into terrain when not in landing configuration
> 6. Excessive downward deviation from glideslope
> 7. Premature descent
> 8. Terrain along future portions of the intended flight Route
>
> A TAWS B system provides indications of imminent contact with the ground in three potentially hazardous situations:
>
> 1. Excessive rate of descent
> 2. Excessive closure rate to terrain (per Advisory Circular (AC) 23-18, to 500 feet above terrain
> 3. Negative climb rate or altitude loss after takeoff
>
> TAWS Alerts
>
> Aural alerts issued by a terrain awareness and warning system warn you about specific situations that present a terrain collision hazard. Using a predictive "look ahead" function.
>
> Based on the aircraft's ground speed, the terrain system alerts you to upcoming terrain. At a closure time of approximately 1 minute, a "Caution! Terrain!" alert is issued. This alert changes to the more serious "Terrain! Terrain!" alert when the closure time reaches 30 seconds. In some areas of the world, this terrain warning may very well be too late, depending on the performance of the aircraft. You need to determine the equipment's criteria and note if the unit makes allowances for lower power output of the powerplant(s) at higher elevations, resulting in lower climb rates than may be programmed into the unit for that aircraft.
>
> A second type of aural alert warns about excessive descent rates sensed by the system ("Sink Rate!") or inadvertent loss of altitude after takeoff ("Don't Sink!").

Regarding the operation of the aircraft, the procedures Manual, in Section 4, Operating Information/Normal Procedures, pages 4.22, 4.23 and 4.24, provided the following on the check before landing:

> Before Landing
>
> 1. Seats, Seat Belts and Shoulder Harnesses - SECURE.

Check seats locked in the desired position. Check seat belts snug and shoulder harnesses latched to the buckle.

2. Avionics and Flight Instrument - CHECK

Check NAV receivers on proper frequency and required heading and course information set. Cross check flight instruments for correct indications.

3. VREF and Fan Speed Settings - CONFIRM.

Refer to performance tables for VREF based on arrival gross weight. Check runway requirements based on gross weight and destination field information. Ascertain N1 and v2 for use in the event of a missed approach.

4. Radar Altimeter - SET (if installed).

Set decision height or minimum descent altitude on EADI. For VFR operation other desired altitude may be set to provide terrain proximity warning. Additional altitude selection (100 feet above DH, for instance) may be set with bug on conventional radio altimeter indicator (if installed).

5. Passenger Advisory Lights - PASS SAFETY.

Turn on SEAT BELT/NO SMOKING signs and emergency exit lights.

6. Passenger Seats - CHECK FULL UPRIGHT, OUTBOARD and POSITIONED AFT or FORWARD to clear exit doors.

This will provide unobstructed access to the emergency exit door.

7. Flaps - T.O. & APPR.

Flaps may be extended to T.O. & APPR below 202 KIAS. Check indicator to verify position.

8. Engine Synchronizer - OFF.

Engine synchronizer should be off to prevent excessive wear with large or frequent throttle movement.

9. Fuel Crossfeed - OFF.

Check CROSS FEED knob OFF and INTRANS IT and FUEL BOOST ON lights extinguished.

10. Ignition - ON.

May preclude flameout should engine problem arise during approach and landing phase.

11. Landing Gear - DOWN and LOCKED.

Pulling gear handle out and moving it DOWN illuminates the HYO PRESS ON and GEAR UNLOCKED lights while gear is extending. Check three green lights on and GEAR UNLOCKED and HYO PRESS ON lights extinguished. Maximum extension and/or operating airspeed varies with airplane serialization and status of compliance with Service Bulletin S8550-32-14.

12. Antiskid System - CHECK ON.

13.Landing Lights - ON.

14. Flaps - LAND.

Flaps may be extended to T.O. & APPR below 202 KIAS and LAND below 176 KIAS. Should be in the LAND position for all normal landings. Check indicator to verify position. Handle must be pushed in to clear T.O. & APPR detent when LAND flaps are desired.

15. Airspeed - VREF

Consistently comfortable and safe landings are best achieved from a stabilized approach. The point at which the airplane should be stabilized with airspeed at VREF to VREF +10 KIAS, full flaps, and the desired descent rate is normally coincident with commencing the final descent to landing. Under instrument conditions, this usually occurs at the final approach fix inbound. During visual approaches, this would be a point approximately equal to a turn onto base leg, adjusted for the altitude difference between the traffic pattern and field elevation.

After passing the instrument approach fix outbound or nearing the airport traffic area, airspeed should be reduced below 202 KIAS and the flaps extended to the APPR (15°) position. Approaching the final instrument fix inbound (one dot from glideslope intercept on an ILS), or a downwind abeam position, extend the landing gear below 176 KIAS. At the point where final descent to landing is begun, extend FULL flaps, establish the desired vertical rate, and adjust power to maintain VREF to VREF +10 KIAS indicated airspeed.

Power management during the approach/landing phase is relatively easy in the Citation II because an N1 setting in the 60-65% range will normally result in desired indicated airspeeds for the various configurations. Depending on air traffic control requirements, thrust necessary for the entire approach can often be set during descent keeping in mind that fan (N1) RPM will decrease slightly for a fixed throttle setting with a decrease in altitude or indicated airspeed. Using a sea level airport with zero wind at a typical landing weight (10,000 pounds), a throttle setting that results in about 60% N1 in close will give up proximate level flight indicated airspeeds of 160 knots clean and 140 with flaps APPR. Gear extended, flaps FULL and commencing an average descent (500 FPM) will result in approximately VREF airspeed. Higher field elevations, landing gross weights and/or headwind component will require a greater power setting.

For maneuvering prior to final approach, minimum airspeeds of VREF +30, VREF+20 and VREF +10 should be maintained clean, flaps APPR and flaps LAND respectively to provide an adequate margin above stall.

Speed control on final should be precise for optimum landing performance and this is best accomplished by establishing VREF airspeed well before crossing the threshold. In gusty wind conditions, it is recommended that one half the gust factor in excess of 5 knots be added to VREF".

Approaching within approximately 50 feet of airport elevation, power should be gradually reduced to counter the acceleration induced by ground effect. Wind velocity and direction will dictate the rate at which the throttles are retarded. In very high surface headwind conditions, as an example, it may be necessary to maintain at or near approach power until close to touchdown. With a tailwind, a fairly rapid power reduction may be necessary in the final descent to landing phase for accurate speed control. In ground effect, where induced drag is reduced, leaving approach power on will cause the airplane to float to a longer touchdown than desired. Retarding the throttles gradually in the final descent will normally result in idle thrust being reached just before touchdown.

16. Autopilot and Yaw Damper - OFF.

Yaw damper OFF to give complete rudder authority to the pilot for landing. If the YAW DAMPER is not turned off it will attempt to override pilot rudder input during touchdown and roll out. Utilize the AP/TRIM DISC button on either control wheel.

17. Annunciator Panel - CLEAR.

18. Pressurization - CHECK ZERO DIFFERENTIAL.

Passing approximately 500 feet above ground level (AGL), check the cabin differential pressure near zero. If it is in excess of about one-half PSI, select a higher cabin altitude and adjust RATE to ascent the cabin. Differential pressure should be at zero for landing. Any pressure existing at touchdown will be dumped by the outflow valves (actuated by the left main gear squat switch) and may cause discomfort. If landing above 12,000 feet pressure altitude, turn the OXYGEN CONTROL VALVE to CREW ONLY and turn pressurization bleed air OFF to preclude passenger mask deployment.

19. Speed brakes - RETRACTED PRIOR TO 50 FEET.

NOTE

Do not allow turbine (N2) RPM to be less than 49%.

The Citation 550/551 Manual, Planning and Performance, section 7, page 7-47, defined:

> Landing
>
> The landing performance charts are based on flying a normal approach at VREF (1.3 Vso) with full flaps extended, to 50 feet above the runway threshold. At that point, thrust is reduced to idle and touchdown is assumed to occur 840 feet from the threshold in no wind conditions. The landing field length given includes distance from the threshold to touchdown.

For the definition of long final straight, ICA 100-37, Air Traffic Services, established:

> ...
>
> 2 DEFINITIONS AND ABBREVIATIONS
>
> 2.1 DEFINITIONS
>
> LONG FINAL STRAIGHT - Flight path in the direction of landing and in the extension of the runway axis, when the aircraft starts the final approach segment, at a distance greater than 7km (4NM) from the touching point or, when the aircraft, in an approach is 15km (8NM) from the touching point.

When commenting on the expression stabilized approximation, the ANAC definitions were taken into account on its website, which contained the following:

> Definition 1
>
> Flight procedure and technique to ensure that the approach and final descent for landing are carried out in accordance with the intended flight path and without the need for excessive maneuvers, such as sudden turns or sudden changes in the rate of descent already in the vicinity of the runway. In these cases, in the event of "destabilization", a go-around procedure must be made.
>
> Source: BRAZIL. Air Force Command. Airspace Control Department. CNS/ATM).
>
> Definition 2
>
> Approach performed in a controlled and appropriate manner in terms of configuration, energy and flight path from a predetermined height up to 50 feet above the threshold or the point where the flaire maneuver is initiated. (ANAC. IS 91-003 Revision A: operational approval for ILS CAT I approaches with required authorization and low visibility takeoffs using the Head Up Guidance System (HGS). Brasilia, 2014).
>
> Available at: http://www2.anac.gov.br/biblioteca/IS/2014/IS91-003A.pdf. (Accessed on: 23SEPT2020).

Still regarding the stabilized approach, the publication prepared by the Flight Safety Foundation's Task Force for the Reduction of Accidents in Approach and Landing (ALAR), translated by the ANAC, pointed out the following recommended elements:

> All flights must be stabilized at around 1,000 feet above the airport's elevation under IMC and 500 feet above the airport's elevation under visual flight weather conditions VMC. An approximation is stabilized when all of the following parameters are met:
>
> 1. The aircraft is on the correct flight path;
>
> 2. Only minor heading/pitch changes are required to maintain the correct flight path;
>
> 3. The speed of the aircraft is not greater than the VREF (reference landing speed) +20 knots of indicated speed and not less than the VREF;
>
> 4. The aircraft is in the correct landing configuration;
>
> 5. The rate of descent is not greater than 1,000 feet per minute; if the approach requires a descent rate greater than 1,000 feet per minute, a specific briefing must be carried out;
>
> 6. The power is properly adjusted to the aircraft configuration and it is not less than the minimum power for the approach, as defined in the aircraft's operating manual;

7. All briefings and checklists have been completed;

8. Instrument landings (ILS) must be conducted within a DOT of the glide-locator ramp; an ILS Category II or III approach must be performed within the expanded band of the locator; during a circular approach, the wings must be leveled at the end when the aircraft is 300tf above the elevation of the airport; and,

9. Procedures for differentiated approach or under abnormal conditions, which require a deviation from the elements of a stabilized approach, require a special briefing.

An approach that becomes unstable below 1,000 feet above the airport's elevation in IMC, or below 500 feet above the airport's elevation in VMC, requires an immediate go-around procedure.

Regarding the definition of runway characteristics and runway contrast, Lt Col R/1 Sergio Koch, in an article on visual approach, published on the blog "*Asas do Conhecimento"*, revealed that a significant number of air accidents occurred during approaches has the influence of several aspects, among which stand out:

Runway characteristics

During the approach, if you are approaching a short, narrow runway, be aware, as you may feel that you are higher than you appear. A pilot usually bases part of his judgment on a mental comparison with a runway he is used to. If your experience is to land on a 2,500 X 45m runway, you can touch much shorter on a 1,000 X 25m runway. On the final approach, you will judge for yourself how farther and therefore higher than he really is. Again, a reminder, continue on the cross check of the instruments until the ring. Irregularities in the runway surface, especially in the rolling terrain, can also cause the impression of a much smaller runway when you lose sight of the opposite threshold, due to a "bump" in the runway.

This illusion that the runway is shorter than normal can result in a more abrupt stop than necessary, with excessive reversal and create an unnecessary problem of keeping the aircraft on the runway.

Runway contrast

Be alert for problems with depth perception when the color of the runway is similar to the surrounding terrain. An extreme example would be to identify that the snow covered the runway, in a night landing and with the runway poorly lit.

But even the least visible conditions can cause serious problems in depth perception, resulting in exceeding or decreasing the limits. A concrete runway over a sand surface in bright sunlight or a strip of macadam (layer of crushed stone about 0.30m thick, agglutinated and compressed) surrounded by dark foliage will have similar difficulty.

The presence of water on the runway in either of the last two examples will increase the effect. Mist or other forms of visibility restrictions will serve to further reduce the color contrast between the runway and the surrounding terrain.

If the visual approach that a pilot is flying is in less than perfect visibility conditions, the pilot must make an assessment of the situation and determine whether it is safe to continue landing and a go-around procedure should be a decision option.

Available at: https://sites.google.com/site/invacivil/temasjadiscutidos/ aproximacao-visual. (accessed on 23SEPT2020).

For a better understanding of the characteristics of runways in relation to illusions in flight, which lead to landing errors, the FAA Aeronautical Information Manual (Source: Aeronautical Information Manual (AIM); Code of Federal Regulations and Advisory Circulars; Chapter 8 Medical Facts for Pilots; Section 1. Fitness for Flight; 8-1-5. Illusions in Flight; page 538), explained the following:

a. Introduction. Many different illusions can be experienced in flight. Some can lead to spatial disorientation. Others can lead to landing errors. Illusions rank among the most common factors cited as contributing to fatal aircraft accidents.

3. Illusions Leading to Landing Errors.

(a) Various surface features and atmospheric conditions encountered in landing can create illusions of incorrect height above and distance from the runway threshold. Landing errors from these illusions can be prevented by anticipating them during approaches, aerial visual inspection of unfamiliar airports before landing, using electronic glide slope or VASI systems when available, and maintaining optimum proficiency in landing procedures.

(b) Runway width illusion. A narrower-than-usual runway can create the illusion that the aircraft is at a higher altitude than it actually is. The pilot who does not recognize this illusion will fly a lower approach, with the risk of striking objects along the approach path or landing short. A wider–than-usual runway can have the opposite effect, with the risk of leveling out high and landing hard or overshooting the runway.

For a comparison, the Final Report A-121/CENIPA/2016 addressed an accident, which occurred previously, with characteristics similar to those dealt with in this report and at the same Aerodrome.

According to the report of that accident, on 17SEPT2016, an aircraft model C-525A (executive jet) took off from the Sócrates Mariani Bittencourt Aerodrome (SSXH), Brumado - BA, to SIRI. The flight was intended to carry four passengers.

After approximately 30 minutes of flight, the aircraft was prepared for the approach to SIRI threshold 11. The aircraft touched the ground with the main landing gears before the runway started. In the race after landing, the plane lost the straight to the right, exiting the runway by its lateral.

When leaving the runway, the auxiliary landing gear ruptured. The plane stopped out of the paved area, with the left-wing tip over the right side of the runway (Figure 23).

The aircraft had substantial damage. The pilot and passengers left unharmed.

Figure 23 - View of the crashed aircraft.

1.20 Useful or effective investigation techniques.

Nil.

2. ANALYSIS.

It was a passengers’ flight between SBJD and SIRI.

Based on the commander's statements and the technical maintenance records available, it was inferred that no failure or malfunction of the aircraft's equipment and systems, including the powerplant, compromised its operation.

The analysis of the CVR data revealed that the existing audio did not match the flight that resulted in the accident.

In the aircraft's documentation, no record of a CVR malfunction was identified.

It was not possible to determine whether the CVR was inoperative at the time of the takeoff. The possibility of having performed the flight in these conditions was contrary to the provisions of letter (e) of section 91.609, of the RBHA 91.

Despite the fact that the ELT equipment was installed and operational, it did not activate in the accident.

The Barra Grande Aerodrome was duly registered, open to air traffic, with its physical and operational characteristics made available by the aeronautical information service, showing the pilots that the operation of the aircraft involved in the accident (550), at that Aerodrome, met the requirements and minimum parameters of operational safety.

Before the takeoff, the aircraft was refueled with 4,178 pounds of JET A1, being with 4,700 pounds of fuel in the tanks.

The SBJD took off at 1458 (UTC) and the aircraft had a weight of 14,371 pounds, therefore, above the PMD, which was 13,300 pounds, contrary to the limitations established in the aircraft's flight manual.

According to the commander's report and the evidence collected, the flight proceeded normally until it entered the visual traffic circuit.

Considering that it is not possible to rely on the information obtained from the flight recorders, hypotheses were formulated based on the evidence collected, even through interviews with the aircraft commander.

From the events that occurred in the final approach, described in this report, notably, between the moment when the aircraft was with the flaps in the 40º configuration and the power levers of the engines positioned at minimum power (Idle), it was inferred that:

1st HYPOTHESIS

With the reduction of the throttles to the minimum power and with the flap activation to 40º, the aircraft continued in a descending trajectory, with a descent rate higher than that recommended for a stabilized approach. The PF corrected the power of the engines to 50% of N1, trying to adjust to the recommended parameters for performing a stabilized approach VFR.

However, such correction was not sufficient, as the aircraft's Operations Manual in Section 4 - item 15, p. 23, Operating Information, foreboded that the recommended power for the approach and landing phases would be between 60% and 65% of N1, an adjustment that would allow the maintenance of the indicated speeds desired for the various configurations employed.

Therefore, the aircraft took a ramp below the expected for a stabilized approach. Upon realizing this condition, less than 1/4 of a nautical mile, about 350m, from the threshold 11, the PF began the maneuver of the go-around procedure.

2nd HYPOTHESIS

With the reduction of the throttles to the minimum power and with the activation of the flaps to 40º (nº 1 - Figure 30), the aircraft continued in a downward trajectory. Concerned about the PM's performance, regarding the fulfillment of the before landing checklist, the PF started to supervise the accomplishment of those tasks, turning his attention to the inside of the cockpit.

When momentarily diverting their attention from the flight, the pilots did not realize that the aircraft had crossed the 500ft AGL (n° 2 - Figure 30) with a rate of descent greater than the ideal and on a ramp below the desired for that situation, therefore, outside the recommended parameters for the VFR stabilized approach.

The aircraft remained with the engine power at a minimum, until the pilots realized they were below the ideal ramp, very close to the threshold 11, less than 1/4 of a Nautical Mile, approximately 350m (nº 3 - Figure 30), when the PF started the go-around procedure (nº 4 - Figure 30).

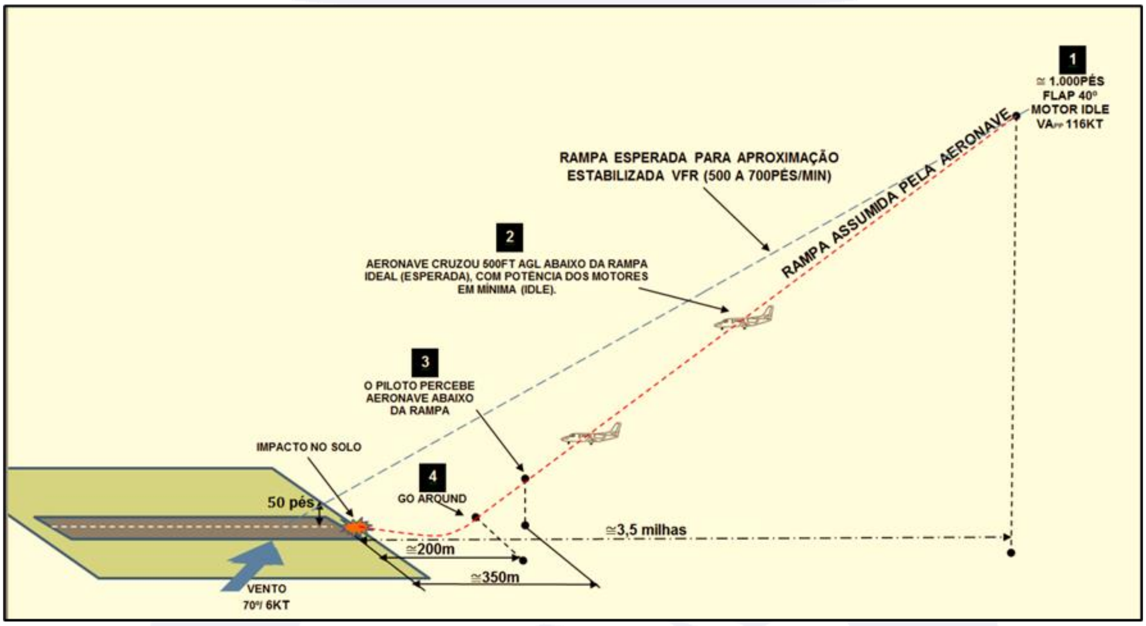

Figure 30 - Approach profile, according to the data from the second hypothesis.

In this context, a possible decrease in the crew's situational awareness level may have favored a late perception in relation to the approach ramp and impaired their ability to correct it in a timely manner to avoid collision with the ground.

It corroborated with these circumstances the fact that the commander divided his attention between the supervision of the tasks performed by the copilot and the piloting, which may have limited his time of action and contributed to the touch before the runway.

It is noteworthy that the commander's little confidence in the copilot's performance, due to the low level of interaction between them, helped him to divide his attention between acting on the aircraft's controls and supervising the copilot's activities.

It is possible that this scenario contributed to the accident, as it would have interfered with the commander's ability to manage the flight and reduced the level of situational awareness of the crewmembers.

A striking feature of reaction aircraft is the delay in engine response during acceleration. This behavior is more critical when the aircraft is already configured for landing, since, in this condition, the drag increases, due to the lowering of the flaps and the landing gear. In this sense, the pilot must anticipate the application of power, in order to avoid loss of speed and height in a critical phase of the operation.

Thus, the second hypothesis was considered to be the most probable, since the commander acknowledged that there was a delay in the acceleration of the aircraft at the moment of the go-around procedure, as a result of the natural reaction time of the engines after the repositioning of the thrust levers to maximum.

If the power levers were already set at 50% N1, as considered on the first hypothesis, the delay in the aircraft's acceleration, while attempting to run, would have been less.

Based on the quote from the aircraft commander, regarding the reaction outlined by the copilot at the critical moment - “one hundred and six knots! Go-around”- it is possible to believe that the go-around procedure started when the aircraft was in the VREF (106KIAS), ruling out the possibility of associating the accident with the loss of lift.

Regardless of the hypotheses raised, the application of commands and the pilotage judgment were inadequate, as the PF did not maintain the appropriate parameters for a stabilized approach.

The report that the PF took two photographs of the runway and of the Aerodrome with his cell phone, during the wind leg, reflected an inappropriate and complacent posture in relation to his primary tasks at that stage of the flight, which may have contributed to the performance of an inadequate traffic profile and, consequently, a destabilized approach.

The fact that the PF decided to prolong the wind leg (approximately 4.5NM), may have influenced his judgment of the approach ramp, since the beginning of the final approach segment took place on a long final straight (Figure 17).

Another fact that must be associated with the previous one, refers to the phenomena of illusions in flight that lead to landing errors. As described in the publication prepared by the Flight Safety Foundation’s ALAR, visual illusions can lead to critical situations and pilots who do not recognize these illusions will perform a lower approach, with the risk of collision with objects or landings below the runway.

In this case, the runway width (23 meters), probably narrower than usual for the pilots involved in the accident, may have created the illusion that the aircraft was higher than it really was, in relation to the distance from the threshold 11.

In addition, the contrast of the runway, when its color resembles of the surrounding terrain, can also cause visual illusions and problems in the pilots' depth perception. The fact that the pilot was surprised by the geography of the terrain (existence of dunes) and the coloring of the runway (asphalt and concrete), may have led to a false visual interpretation, with a reflection in the evaluation of the parameters related to the approach ramp.

These aspects may have led the pilots to choose the flap configuration at 40º, as well as the reduction of the throttles to Idle, still at the beginning of the long final straight, between 1,200ft and 1,000ft, which also contributed to an inadequate judgment of the PF, believing that there was enough time to supervise the PM's tasks, without compromising the operation of the aircraft.

As for the use of CRM techniques in the accident in question, it was observed that there was not an adequate management in that critical phase of the flight. This fact prevented the perception and the timely reaction of the crew, in order to correct the approach ramp, adapting it to the recommended parameters for a stabilized VFR approach.

In those circumstances, the best interaction between the pilots should contribute to the proper management of the tasks, as well as to the correct advice of the PM, culminating in the performance of the go-around procedure by the PF, before the accident becomes irreversible.

It is possible to consider the presence of this aspect in the circumstances described in the first hypothesis, being characterized by the late recognition of the need to perform a go-around procedure, or on the second hypothesis, by the fact that the crew allowed the aircraft to cross the 500ft AGL, in an unstabilized manner, without start the go-around procedure.

In the two hypotheses addressed, it was observed that the failure in communication between the pilots resulted in the lowering of situational awareness, with repercussions for the timely adoption of the solution to the problem (go-around).

According to the reports obtained, the copilot performed the callouts in a low volume of voice, notably in the visual traffic, to the point of being asked to repeat some checklist items, as well as to verbalize the speeds with a higher voice intensity.

It is noteworthy that both pilots did not use the head phones at the time. According to the commander's previous medical information, the tests carried out in his assessments signaled hearing loss at the limit of the critical range for aviation, despite this, it was not possible to ensure that this fact came to compromise the pilot's performance during the flight.

However, according to the commander's report, it is possible that the tone and intensity of the voice used by the copilot during the performance of the callouts, associated with the lack of the use of head phones, may have influenced his understanding of the information that was being transmitted.

These communication failures may have impaired the flight management, to the point of interfering with the crew's ability to perceive, in a timely manner, that they were below the ideal ramp.

Although the aircraft was equipped with TAWS/EGPWS, in accordance with the legislation in force, it was found that such a resource was not used by the crewmembers, since the information of the destination Aerodrome (SIRI) was not found in the database of the equipment.

Although the traffic was performed in visual conditions, the crew could have relied on the issuing of TAWS/EGPWS alerts regarding the high rate of descent of the aircraft or the critical conditions in relation to the terrain and the obstacles ahead.

In the context of the occurrence, the alerts (visual and aural) coming from the TAWS/EGPWS could have helped in raising the pilots' situational awareness in relation to the approach ramp and, consequently, anticipated the commander's reaction in effecting the correction of the aircraft's trajectory.

One aspect that drew the attention of the investigators was the fact that this accident had characteristics similar to another one that occurred on 17SEPT2016, at the same Aerodrome, involving an executive jet with an operating profile similar to the PT-LTJ's one. In that accident, there was also the touch of the aircraft before the threshold 11, with runway exit, referring to a deepening of the research in relation to the infrastructure of the Barra Grande Aerodrome (SIRI).

Initially, it was taken into account that, during the flight planning, the pilots of the PT-LTJ studied the intervening variables in that type of operation, concluding that the conditions of the Aerodrome were compatible with the characteristics of the aircraft.

However, it is possible that, during the preparation work for the flight, the pilots did not take into account the impossibility of using the EGPWS that equipped the aircraft and the lack of a visual indicator system approach ramp at the Aerodrome.

The absence of visual ramp and approach indicator systems was not treated as a deficiency of the infrastructure, since, as it is a private Aerodrome, there was no regulatory device making it mandatory to install these in SIRI.

Likewise, the existence of counter-fire and first aid services was not required by the legislation applicable to its operation.

In the course of the present investigation, the ICA Ordinance No. 154 / SAGA, of 21APR2020, dealing with the PBZPA to the Barra Grande Aerodrome, published changes to the physical characteristics of that Aerodrome, which have already been previously mentioned.

The processing of the respective administrative process, regarding the modifications to the Aerodrome characteristics, took place in accordance with the formalities provided for in the ANAC Resolution No. 158, of 13JUL2010, based on the information provided by the Aerodrome operator, since there were no requirements for current projects for private Aerodromes, established by the RBAC 154, mandatorily applied only to public Aerodromes.

As the commander did not have greater knowledge about the professional part of the copilot, as they had only performed one flight together, he started to check the checklist procedures performed by the copilot, making sure that those tasks were correctly performed, diverting his attention from the piloting and raising his workload at a critical stage of flight.

Therefore, the observations related to the medical aspect allowed us to deduce that, before the flight in question, the aircraft commander was not subjected to a workload that pointed to the presence of acute or chronic fatigue that could have interfered with his performance and his decision-making capacity.

In addition, the use of the reported medications did not point to dangerous associations that could compromise the operational safety.

It should be noted, however, that the lack of records in the health inspection forms analyzed, with regard to any type of medical follow-up on the commander's hearing loss, can be seen as a vulnerability in conducting the health inspections of airmen, which may have an impact on operational safety.

3. CONCLUSIONS.

3.1 Facts.

a) the pilots had valid CMAs;

b) the pilot had the PLA License and valid C550 aircraft type Rating and IFRA Rating;

c) the copilot had the PLA License and valid C550 aircraft type Rating and IFRA Rating;

d) the pilots were qualified and had experience in the type of flight, but the copilot had little experience at the aircraft’s model;

e) the aircraft had valid CA;

f) at the moment of the accident, the aircraft was within the balance and weight limits;

g) considering the date of the last IAM, the airframe and engines logbook records were updated;

h) the logbook was consumed by the fire at the time of the accident;

i) it was not possible to accurately survey the hours flown by the aircraft between the date of the last inspection and the date of the accident;

j) the aircraft took off with a weight above the prevised in its operating manual;

k) the aircraft was carrying eight passengers;

l) the flight en route went smoothly;

m) the weather conditions were favorable for the flight;

n) there were no communication problems with the control agencies;

o) visual traffic was carried out at SIRI;

p) in the final approach, the aircraft hit a signpost and, then, it hit the threshold 11 ravine, with the landing gear collapsing;

q) the PF declared that, after the collision against the ravine, he reduced the power of the engines and commanded the touch of the aircraft on the runway;

r) without landing gears, the aircraft dragged for 147 meters, until it stopped on the left side of the runway and caught fire;

s) there was no record of triggering the ELT;

t) the aircraft was destroyed;

u) one crewmember died and the other suffered a serious injury; and

v) four passengers died and four passengers suffered serious injuries.

3.2 Contributing factors.

- **Control skills – a contributor.**

The inadequate performance of the controls led the aircraft to make a ramp that was lower than the ideal. This condition had the consequence of touching the ground before the runway’s threshold.

- **Attention – undetermined.**

During the approach for landing, the commander divided his attention between the supervision of the copilot's activities and the performance of the aircraft's controls. Such circumstances may have impaired the flight management and limited the reaction time to correct the approach ramp.

- **Attitude – undetermined.**

The report that the commander took two photographs of the runway and of the Aerodrome with his cell phone, during the wind leg, reflected an inadequate and complacent posture in relation to his primary tasks at that stage of the flight, which may have contributed to this occurrence.

- **Communication – undetermined.**

As reported by the commander, the low tone and intensity of voice used by the copilot during the conduct of callouts, associated with the lack of use of the head phones, limited his ability to receive information, which may have affected his performance in management of the flight.

- **Crew Resource Management – a contributor.**

The lack of proper use of CRM techniques, through the management of tasks on board, compromised the use of human resources available for the operation of the aircraft, to the point of preventing the adoption of an attitude (go-around procedure) that would avoid the accident, from the moment when the recommended parameters for a stabilized VFR approach are no longer present.

- **Illusions – undetermined.**

It is possible that the width of the runway, narrower than the normal for the pilots involved in the accident, caused the illusion that the aircraft was higher than expected, for that distance from the thrashold 11 of SIRI, to the point of influence the judgment of the approach ramp.

In addition, the fact that the pilot was surprised by the geography of the terrain (existence of dunes) and the coloring of the runway (asphalt and concrete), may have led to a false visual interpretation, which reflected in the evaluation of the parameters related to the approach ramp.

- **Piloting judgment – a contributor.**

The commander's inadequate assessment of the aircraft's position in relation to the final approach ramp and landing runway contributed to the aircraft touching the ground before the thrashold.

- **Perception – undetermined.**

It is possible that a decrease in the crew's situational awareness level resulted in a delayed perception that the approach to landing was destabilized and made it impossible to correct the flight parameters in a timely manner to avoid touching the ground before the runway.

- **Flight planning – undetermined.**

It is possible that, during the preparation work for the flight, the pilots did not take into account the impossibility of using the perception and alarm system of proximity to the ground that equipped the aircraft, and the inexistence of a visual indicator system of approach ramp at the Aerodrome.

- **Other / Physical sensory limitations – undetermined.**

The impairment of the hearing ability of the aircraft commander, coupled with the lack of the use of head phones, may have interfered with the internal communication of the flight cabin, in the critical phase of the flight.

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-144/CENIPA/2019 - 01 **Issued on 08/19/2021**

Work with the aircraft operator, in order that risk assessment procedures are adopted for the operation of turbojets, in Aerodromes whose data are not included in the data bank of the ground proximity perception and alarm system (TWAS / EGPWS) and that are not equipped with a visual approach ramp indicator system.

A-144/CENIPA/2019 - 02 **Issued on 08/19/2021**

Work with accredited medical clinics to carry out health inspections for airmen so that, in the case of health conditions with a prognosis of worsening, and which may result in damage to the flight safety, the indication of monitoring the evolution of such conditions is objectively and clearly recorded.

A-144/CENIPA/2019 - 03 **Issued on 08/19/2021**

Disseminate the lessons learned in the present investigation, in order to alert pilots and civil aviation operators about the importance of faithful compliance with aircraft operating rules and flight manuals, in addition to the use of appropriate CRM techniques.

A-144/CENIPA/2019 - 04 **Issued on 08/19/2021**

Disseminate the lessons learned in the present investigation, in order to alert pilots and operators of the Brazilian civil aviation about the importance of correct flight planning and the performance of stabilized approaches, seeking to alert them to the risks arising from the operation of turbojet aircraft in Aerodromes that are not equipped with a visual approach ramp indicator system and whose data are not included in the data bank of the respective ground proximity perception and alarm system.

5. CORRECTIVE OR PREVENTATIVE ACTION ALREADY TAKEN.

None.

On August 19th, 2021.