COMANDO DA AERONÁUTICA

CENTRO DE INVESTIGAÇÃO E PREVENÇÃO DE ACIDENTES AERONÁUTICOS

FINAL REPORT
A - 131/CENIPA/2013

OCCURRENCE:	ACCIDENT
AIRCRAFT:	PR-OKK
MODEL:	BE58
DATE:	16 JULY 2013

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 item 3.1, 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 16 July 2013 accident with the BE-58 aircraft, registration PR-OKK. The aeronautical accident was classified as “loss of control on the ground”.

During the take-off run, the pilot lost control of the aircraft, exited the runway, and collided with the terrain in a steep slope.

The aircraft exploded after the final impact, and was consumed by a raging post-impact fire.

The aircraft occupants (a pilot and six passengers) perished in consequence of the crash.

An accredited representative of the National Transportation Safety Board – NTSB (USA) was designated for participation in the investigation.

CONTENTS

GLOSSARY OF TECHNICAL TERMS AND ABBREVIATIONS

ANAC	Brazil's National Civil Aviation Agency
CA	Airworthiness Certificate
CENIPA	Aeronautical Accident Investigation and Prevention Center
CG	Center of Gravity
CHT	Technical Qualification Certificate
CMA	Aeronautical Medical Certificate
DCTA	Aerospace Technology and Science Department
DECEA	Airspace Control Department
IAM	Annual Maintenance Inspection
ICA	Command of Aeronautics' Instruction
IFR	Instrument Flight Rules
IML	Forensic Medicine Institute
MLTE	Airplane, Multi-engine, Land (AMEL)
MNTE	Airplane, Single-engine, Land (ASEL)
PLA	Airline Transport Pilot (Airplane category)
PMD	Maximum Take-Off Weight (MTOW)
PPR	Private Pilot (Airplane category)
RAB	Brazilian Aeronautical Register
SBEG	ICAO location designator – *Eduardo Gomes* Aerodrome
SERIPA	Aeronautical Accident Investigation and Prevention Service
SIPAER	Aeronautical Accident Investigation and Prevention System
SWYN	ICAO location designator – *Flores* Aerodrome
TWR	Control Tower
UTC	Coordinated Universal Time
VFR	Visual Flight Rules
VMCA	Aircraft Minimum Control Speed
ANAC	Brazil's National Civil Aviation Agency

1. FACTUAL INFORMATION.

Aircraft	**Model:** BE58 **Registration:** PR-OKK **Manufacturer:** Raytheon Aircraft	**Operator:** COTRAP Constr. e Transport. Pioneiro Ltda.
Occurrence	**Date/time:** 16 July 2013 / 10:22 UTC **Location:** Eduardo Gomes Aerodrome (SBEG) **Lat.** 03º02'09"S **Long.** 060º03'08"W **Municipality – State:** Manaus - Amazonas	**Type(s):** Loss of control on the ground

1.1 History of the flight.

At 10:22 UTC, the aircraft started take-off run in SBEG, on a transport flight destined for SWYN, with the pilot and six passengers on board.

While still on the take-off run, the aircraft inadvertently turned to the left and exited the runway, traveling approximately 690 meters on a trajectory forming an angle of 30º with the runway center line, and collided with a terrain declivity next to taxiway Alfa.

The aircraft exploded after the impact, and was destroyed by a post-impact fire.

The pilot and two of the passengers perished in the crash site. The other three passengers died in hospital a few days later as a result of severe burns.

1.2 Injuries to persons.

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

1.3 Damage to the aircraft.

The aircraft was completely destroyed by the impact, explosion, and post-impact fire which consumed the fuselage, wings and the other aircraft components.

1.4 Other damage.

There was damage to the aerodrome operational fence.

1.5 Personnel information.

1.5.1 Crew's flight experience.

Hours Flown	
	Pilot
Total	4,351:30
Total in the last 30 days	77:25
Total in the last 24 hours	00:00
In this type of aircraft	597:45
In this type in the last 30 days	35:50
In this type in the last 24 hours	00:00

N.B.: Data relative to the hours flown provided by the operator.

1.5.2 Professional formation.

The pilot did his Private Pilot course (Airplane category) at the Aeroclube do Paraná in 1989.

1.5.3 Category of licenses and validity of certificates.

The captain had an Airline Transport Pilot license (Airplane category). His technical qualification certificates regarding E110 aircraft, AMEL and ASEL were valid. He also had a valid IFR rate.

1.5.4 Qualification and flight experience.

The pilot had qualification and enough experience for the flight in question.

1.5.5 Validity of medical certificate.

The pilot had a valid aeronautical medical certificate (CMA).

1.6 Aircraft information.

The airplane (TH-660) was manufactured by Raytheon Aircraft in 1975.

The airworthiness certificate (CA) was valid.

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

The last inspection of the aircraft (Type "50 hours") was done on 10 June 2013 by a company maintenance mechanic, and the aircraft flew 32 hours after the inspection.

The last overhaul ("Type IAM/100-hours") was done on 29 January 2013 by a workshop homologated by the ANAC. After the overhaul, the aircraft flew 82 hours.

1.7 Meteorological information.

The prevailing weather conditions were VMC (wind calm).

1.8 Aids to navigation.

Nil.

1.9 Communications.

The transcript of the communications between the aircraft and the SBEG control tower, shows that the aircraft was granted clearance for take-off approximately 58 seconds after the landing of an Airbus 320 (TAM 3747), which, according to the ICA 100-37 – Air Traffic Services (item 3.22.2), belongs to the MEDIUM size aircraft category (between 7,000 kg and 136,000 kg).

No warning was transmitted by the ATC unit to the departing LIGHT aircraft on the possible presence of wake turbulence after the landing of the MEDIUM size aircraft.

In accordance with the ICA 100-37 (item 3.23.3.22), the ATC unit must transmit a warning of possible wake turbulence, with respect to the flights specified in 3.23.3.2.1 of the same Instruction, as well as when deemed necessary for other reasons. The pilot in command of the aircraft involved has the responsibility of ensuring that the separation with the preceding aircraft is acceptable if it belongs to a heavier wake turbulence category. If there is a need for additional separation, the flight crew shall inform ATC, stating their needs.

1.10 Aerodrome information.

SBEG is a public aerodrome under INFRAERO administration, operating VFR/IFR during day- and night-time.

The runway is paved with asphalt, with thresholds 10/28, measuring 2,700m x 45m, at an elevation of 264 feet.

1.11 Flight recorders.

Neither required nor installed.

1.12 Wreckage and impact information.

The accident occurred next to Alpha taxiway, in an area with accentuated declivity, 10 meters lower than the taxiway surface. In the area, there was vegetation with small to mid-size trees.

Figure 1 – Aircraft crash site (next to taxiway *Alpha*).

The aircraft first hit the treetops, resulting in breakage of the shaft and detachment of the right engine propeller. Then, the aircraft assumed a pitch-down attitude, and crashed into the ground at a speed of approximately 65kt, according to data transmitted by the transponder equipment to ATC units.

There was no detachment of any aircraft parts prior to the first impact, and the wreckage was concentrated.

1.13 Medical and pathological information.

1.13.1 Medical aspects.

On account of the state of the pilot’s remains, the forensic medicine institute was not able to carry out the pertinent exams.

No relevant evidence of medical nature was found associated with the accident, according to the history of the most recent pilot’s health-checkup results.

1.13.2 Ergonomic information.

Nil.

1.13.3 Psychological aspects.

Individual information

In the days preceding the accident, the pilot had also been working as a captain for an air-taxi company and as a freelancer for a contractor, both belonging to the same owner.

His transition from copilot to captain in the company was swift. In the accident, he was flying a private aircraft which belonged to the owner of the company.

According to the information gathered, the pilot was going through personal problems, which had repercussions on his social relationship. He also appeared insecure at work, in view of the company's instability.

Psychosocial information

According to interviewees, the pilot had few friends in the work environment and in his private life.

Some friends of the pilot reported that he had gone through personal problems and was complaining of his work routine. He had expressed even desire to leave work and go back to your hometown

1.14 Fire.

The fire began shortly after the aircraft crashed into the ground, as can be seen in the images recorded by airport security cameras.

Only a section of the empennage did not catch fire, but all the rest was burnt to ashes.

The ignition source may have been either the hot parts of the engine or friction of the aircraft against the ground.

1.15 Survival aspects.

Three passengers, who had been occupying the rear seats, abandoned the aircraft with various burns to their bodies, and were taken to hospital by the Aerodrome Fire Brigade. Since it was not possible to interview them at the hospital, the Investigation Commission could not learn about the details of their evacuation from the aircraft.

The pilot and the other two passengers perished in the crash site.

1.16 Tests and research.

Due to the fact that the post-impact fire consumed the aircraft almost entirely, the go-team at the Field Investigation could not find evidence of mechanical failure or malfunctioning of any aircraft systems.

The research focused on examining the aircraft engines and propellers, as well as on verifying technical documentation of the equipment kept by the operator.

The research showed that the aircraft maintenance and the logbook records were up-to-date.

The propellers and both engines were disassembled in the presence of the investigators at a workshop certified by the ANAC. All of the items of the assemblies were intact and functional, thus indicating that there had not been any failure of the components, and that the engines were operating normally at the time of the accident.

For these tests to be carried out, in addition to an Engineer of the Aerospace Technology and Science Department (DCTA), a representative of the engine manufacturer in Brazil was invited, and monitored the disassembly of the engines.

The Investigation Technical Report issued by the DCTA pointed out that both engines were operating normally at the time of the accident, and none of its parts and accessories showed any abnormalities or discrepancies.

However, it became clear that the right engine was developing power at the moment of crash, while the left engine showed evidence of being in operation but, apparently, with no power.

The evidence as to the operation of the engines was obtained from the analysis of the marks existing on the right and left propellers. The right propeller had the tips of its blades bent forward, while the tips of two blades of the left propeller were bent backwards, with the third one presenting light transversal scratches to its leading edge.

1.17 Organizational and management information.

The accident aircraft was private, and belonged to the owner of the company for which the pilot worked. The pilot flew this aircraft as a freelancer. The mechanic of this aircraft was also an employee of the company.

The air taxi company was experiencing difficulties, and its certification to operate had been suspended on account of operational issues. They were providing services to an oil company at the moment.

This situation ended up creating a climate of instability and uncertainty within the air company, since the employees did not know whether they would keep their jobs.

At the company, the investigation commission verified that the pilot had not taken up any courses or upgrades recently.

There was no formal system used by the organization to recruit, select, monitor and evaluate the performance of its professionals, and there was no monitoring of employees by means of meetings and training.

1.18 Operational information.

The aircraft was above the weight and center of gravity (CG) limits specified by the manufacturer.

The take-off was scheduled to take place at around 10:30 UTC (06:30, local time), so the pilot had to arrive at 05:30 (local time), to carry out the pre-flight check, provide for aircraft refueling, and file the flight plan.

The prevailing weather conditions were VMC. The wind was calm, with no clouds on the location and along the route.

The aircraft was refueled with 398 liters of fuel, totaling 480 liters (approximately 4 hours and 30 minutes of endurance). The total weight was estimated to be 2,563kg, that is, about 114kg above the maximum take-off weight of 2,449kg.

At about 10:15 UTC, the aircraft started taxiing to the threshold of runway 10 in SBEG. The RT-communications between the aircraft and the control tower were uneventful.

Upon reporting the holding point, the captain was instructed to maintain position, and wait for the landing of an A320 aircraft that was on final.

The Airbus landed at 10:21:15 UTC, touching down 600 meters past the approach end of the runway. Shortly after, the captain of the PR-OKK aircraft requested clearance to enter the runway in use, and was instructed by the tower controller to line up and wait on the threshold of runway 10.

The control tower, after visually verifying that the landing aircraft had vacated the runway, cleared the PR-OKK for take-off (ATD 10:22:25), without giving any further information.

The take-off run was uneventful up to a distance of 450 meters along the runway. From this point onward, however, at a speed of about 60 kt, the aircraft abruptly veered off to the left at an angle of 30º with the runway center line.

At this new heading, the aircraft began to float over the ground and accelerate to the final speed of about 65 kt, leaving intermittent marks of the landing gear on the ground.

The aircraft exited the runway via the left side, and crossed the area between the runway in use and taxiway Alpha. Upon reaching the lateral limit of taxiway Alpha, the aircraft abruptly collided with the ground, bounced and had the first impact with the tree-tops in a slope approximately 10 meters deep next to the runway.

The first impact resulted in separation of the right engine propeller, and the final impact with the ground occurred with the aircraft in a pitch-down attitude at the end of the slope.

The entire sequence leading to the accident, from the start of the takeoff run until the moment of the final impact of the aircraft with the ground lasted about 40 seconds.

The distance traveled by the aircraft after veering off to the left and crashing into the slope was 693 meters, and the time spent was 18 seconds.

According to the aerodrome firefighters, who arrived at the scene about two minutes after the impact, four occupants managed to abandon the burning aircraft...

The control tower was informed of the accident by another aircraft which was at the holding point during the takeoff of the accident aircraft.

The airfield was interdicted for a few hours until completion of the Field Investigation by go-team of SERIPA VII, and was later reopened by the INFRAERO.

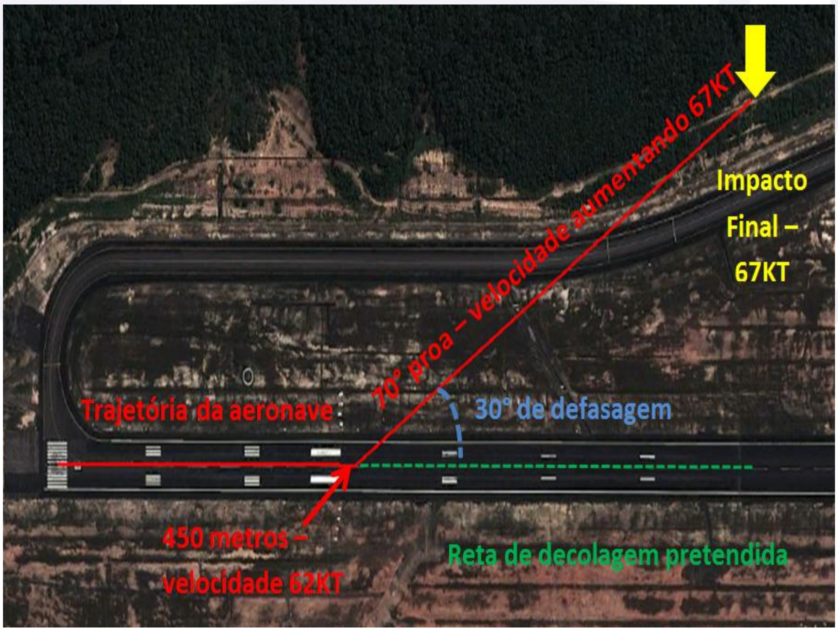

Figure 2 – Trajectory of the aircraft until the final impact.

1.19 Additional information.

Wake turbulence

All aircraft produce wake turbulence, more properly called wingtip vortices or wake vortices. The vortices are formed on any aerodynamic surface (airfoil) that produces lift. The lift is generated by the creation of a pressure differential along the surface of the wings. The lowest pressure occurs along the upper surface of the wing, and a higher pressure is formed under the wing. The airflow always moves toward the low pressure area. This causes air to move on the wing, from the inner side to the wing tip, generating escape vortices at the wing tip.

The same pressure differential causes the airflow over the wing to move in the direction opposite to the escape vortices, from the wing tip inwards, forming small vortices on the trailing edge of the wing, called contour vortices. Viewed from the rear, the vortices formed at the tip of the left wing rotate clockwise, and the vortices formed at the tip of the right wing rotate in a counterclockwise direction, as shown below.

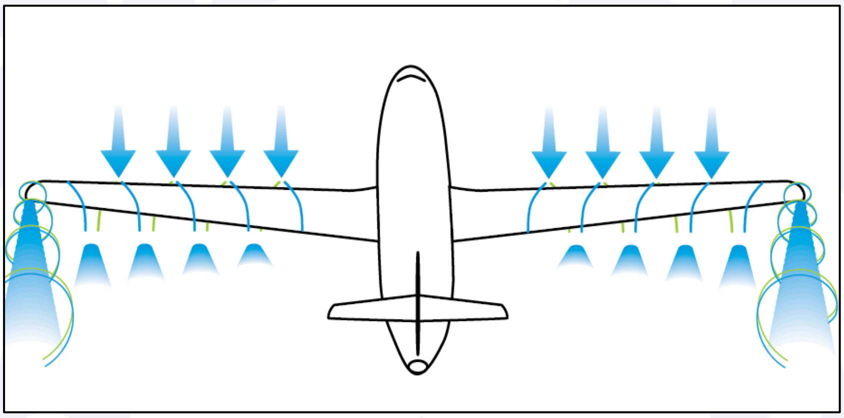

Figure 3 – Vortices formed on the surface of aircraft wings.
Source – Civil Aviation Authority of New Zealand – Good Aviation Practice (GAP).

Wake turbulence characteristics (vortices)

Since there is not a technique for the visualization of the wake turbulence caused by an aircraft, it is important to understand its physical characteristics so that one is able to mentally anticipate potential areas of turbulence encounter.

The main characteristics of wake turbulence are:

- Sink rate: 300 to 500 ft./min;
- Stabilization 500-900 meters below the aircraft originating the wake;
- Lateral movement speed of 5 kt upon reaching the ground.

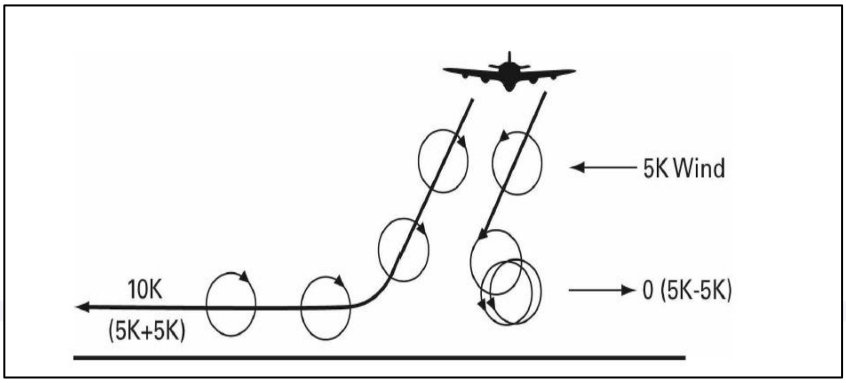

Figure 4 – Vortex movement under calm wind conditions, as viewed from behind the generating aircraft.

Duration period:

- About 30 seconds, with a wind speed of 5 to 10 kt;
- Up to 85 seconds when the wind speed is less than 5 kt;
- More than 100 seconds when there is no wind.

<u>Factors which foster the onset of wake turbulence</u>

The following factors increase the likelihood of wake turbulence:

- Heavy aircraft, at low speed and 'clean' configuration (without landing flaps and landing gear);
- Parallel or intersecting runways;
- Visual Meteorological Conditions (VMC), due to the reduction of separation between aircraft on visual approaches;
- Cross-winds at 3-10 kt, or tailwind;
- Stable atmosphere, temperature inversion (at sunrise, for example);
- Flat surrounding terrain;
- On the final approach, a tail wind may bring vortices back to the trajectory of descent.

<u>Aircraft categories according to generated wake turbulence</u>

The ICA 100-37 - Air Traffic Services (section 3.22.1) reads:

> "The separation minimums from wake turbulence are based on the grouping of aircraft types into three categories according to their maximum certified take-off weight ".

The three categories for use (ITEM 9) in the flight plan form are:

- HEAVY (H) - aircraft with maximum take-off weight of 136,000kg (300,000lb) or more;
- MEDIUM (M) – aircraft with maximum takeoff weight of less than 136,000kg (300,000lb), and more than 7,000kg (15,500lb); and
- LIGHT (L) – aircraft with maximum takeoff weight of 7,000kg (15,500lb) or less.

Maintaining the scope, and considering the above legislation, the ICA 100-37 also establishes a minimum separation with respect to wake turbulence, taking into account the three aircraft-categories, HEAVY (H), MEDIUM (M) and LIGHT (L).

Basically, the legislation calls for time-slots in sequential takeoffs and landings of aircraft. More specifically in relation to the occurrence, the item 3.23.3.2.6 describes the need to apply a minimum time separation of 2 minutes between a LIGHT aircraft and a MEDIUM aircraft when operating on a runway with a displaced landing threshold when:

a) A LIGHT or MEDIUM aircraft are departing after a HEAVY aircraft has landed; and a LIGHT aircraft is departing, after a MEDIUM aircraft has landed;

The DOC 4444 – ATM/501- Air Traffic Management of the International Civil Aviation Organization (ICAO), item 5.8.4, establishes the same separation minimums of the item 3.23.3.2.6. This latter is an accurate translation of the content stipulated by ICAO.

The Airbus A320 aircraft

The Airbus A320 is a MEDIUM size aircraft manufactured by Airbus, with a Maximum Take-Off Weight (MTOW) of 77,000kg.

The BE58 aircraft

The Baron 58 is a small size twin-engine aircraft, originally developed by Beech Aircraft Corporation, and subsequently produced by Beechcraft Raytheon Aircraft. The Baron is a variant of the Beechcraft Bonanza, and was first introduced in 1961. It has a Maximum Take-Off Weight of 2,449kg, and carries up to five passengers. The propellers of this model turn to the same side, clockwise to those who look from inside the cabin. This makes the left engine the critical one.

Pilots who flew this model of aircraft reported at informal interviews that loss of power of the left engine at take-off requires proficiency from the pilot in command for the execution of emergency procedures, mainly in relation to the use of pedals and rudder trim.

Critical engine in twin-engine aircraft.

The figure below shows two situations with the objective of examining the relationship between the angles of attack of propeller blades, associating the movement of the downward segment with the movement of the upward segment.

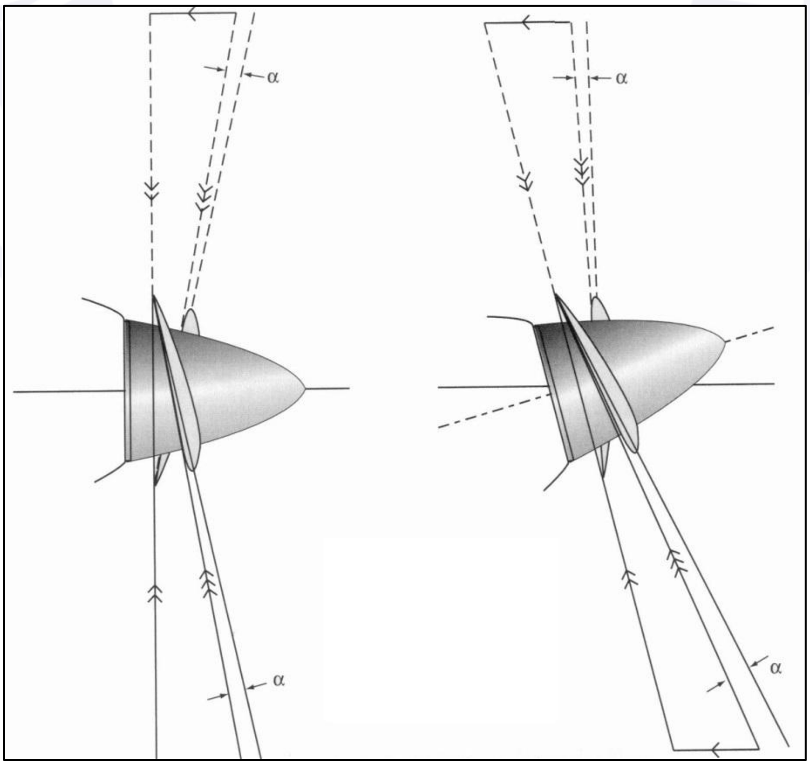

Figure 5 – Blades with different angles of attack.

On the left, the aircraft is at a zero-degree angle of attack, and the angle of attack of the blade moving upwards is equal to the one moving downwards.

On the right, at high angles of attack, the angle of attack of the blade moving downwards is approximately twice the one of the blade moving upwards.

The conclusion is that when the aircraft is put at higher angles of attack, the moment of greatest traction in a propeller will occur when the blade is moving downward.

In Figure 6, an aircraft is depicted with a zero-degree angle of attack, resulting that the traction is identical, whatever the direction of movement of the blade: upwards or downwards.

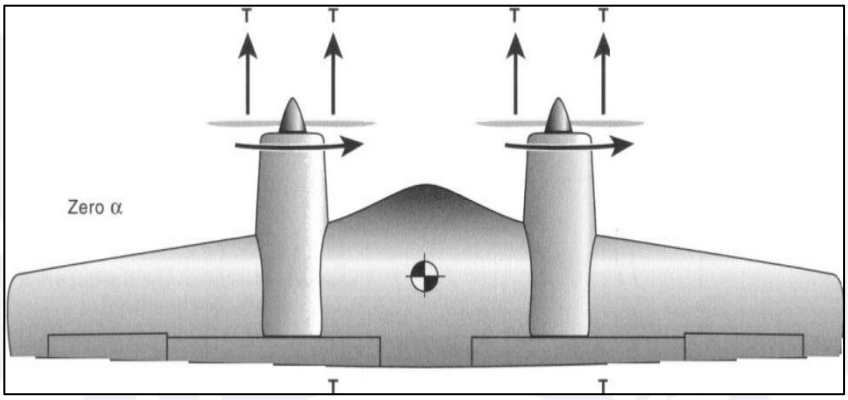

Figure 6 – Engines with identical traction – 0º angle of attack.

One can see that at an angle of attack greater than zero, a contingent failure of the left engine creates the most critical situation for the pilot, since the traction of the right engine is applied to a much longer arm measured from the aircraft center of gravity.

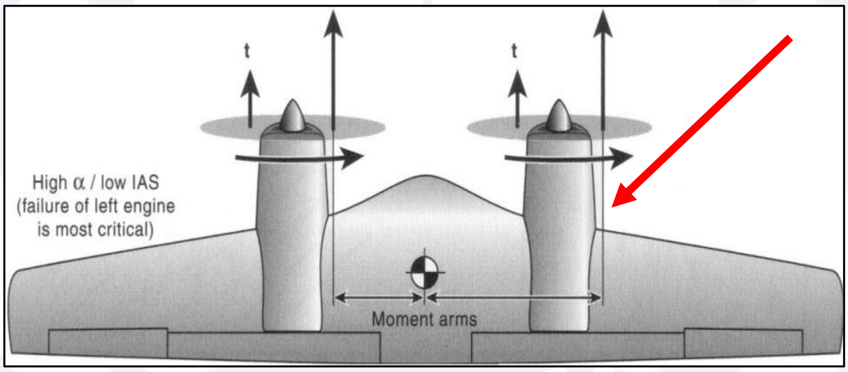

Figure 7 – Higher traction on starboard engine – positive angle of attack.

Therefore, the left engine is the critical one for this aircraft, i.e., the engine whose failure in a low-speed, high angle of attack situation (such as at take-off) results in higher amplitude in the movement of the controls to compensate for the single-engine flight condition.

In order to prevent such problem, counter-rotating engines were developed (Figure 8), which solves the problem of having to operate an aircraft with critical engines. Thus, aircraft with counter-rotating propellers do not have a critical engine.

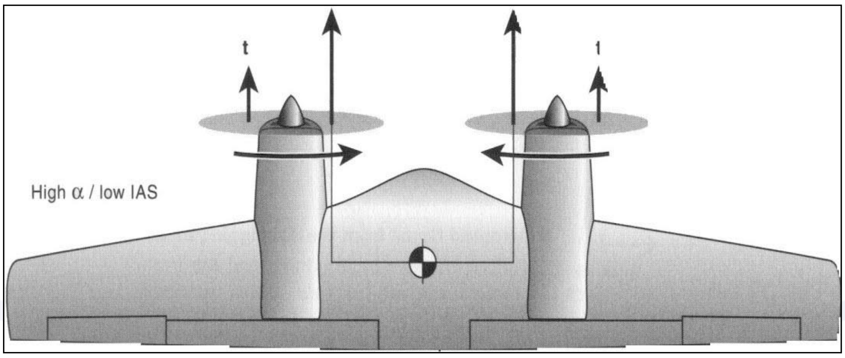

Figure 8 – Identical tractions on counter-rotating engines.

The concept presented above relates only to aircraft certified under the RBHA23. In relation to jet aircraft, there are other concepts that must be considered to determine whether or not a critical engine exists.

1.20 Useful or effective investigation techniques.

Nil.

2. ANALYSIS.

With regard to the planning of the flight, it was observed that the weight of the aircraft was not correctly considered. The total fuel available in the aircraft before the flight was 480 liters, which corresponded to a weight of 345.6 kg of aviation gasoline, an amount of fuel that was higher than the necessary for the flight.

Since the weight and balance form of the aircraft was lost in the crash, the weights of passengers, pilot, and baggage were added to the basic weight of the aircraft, reaching an estimated 2,563.6 kg.

The Maximum Take-Off Weight (MTOW) established for the aircraft in the operations manual and according to the Brazilian Aeronautical Register (RAB), was 2,449 kg. Therefore, there was an excess weight of around 114.6 kg, which, in a contingent engine failure at take-off, could influence the pilot's ability to maintain the Aircraft Minimum Control Speed (VMCA), and the overall aircraft performance.

From the analysis of the recordings of the communications between the aircraft and the control tower, it was noticed that the pilot maintained a calm tone in the use of radiotelephony, denoting a calm and confident behavior during the pre-flight procedures.

When the aircraft reached the holding point of runway 10, the control tower instructed the pilot to hold position, due to an Airbus A320 on the final approach.

The A320 aircraft which landed moments before the BE58 take-off had a Maximum Take-Off Weight of about 77,000 kg, within the MEDIUM size category, according to the ICA 100-37 - Air Traffic Services (aircraft between 7,000 kg and 136,000 kg MTOW).

The above mentioned legislation also prescribed that, in case of displaced thresholds, a 2-min interval was to be respected before clearance for take-off could be granted to a LIGHT aircraft after the landing of a MEDIUM size aircraft in order to minimize the effects of contingent wake turbulence.

Both Brazilian and international legislations establish such interval only for the operation with displaced thresholds.

From the analysis of the timeline of the INFRAERO video recordings made on the day of the occurrence, the PR-OKK pilot was granted clearance for take-off 1min and 5 seconds after the landing of the A320.

In theory, there was no violation, both on the part of the pilot and the air traffic controller, since the runway in use for takeoffs and landings did not have displaced thresholds.

However, the images show that, on account of operational reasons, the MEDIUM size aircraft touched down on the runway at a point located 650 meters after the approach threshold, near the end of the first one-third of the runway, in a situation similar to that of a displaced threshold. It is possible that, due to the existing meteorological conditions (wind calm at dawn, and with temperature inversion), the effects of wake turbulence lingered over the runway in use for more than 100 seconds, according to studies related to the event.

Both the controller and the pilot in command did not consider this possible effect, which may have become an aggravating factor to the occurrence, since the vortex wake turbulence moving laterally at a speed of 5kt upon hitting the ground, increased the tendency of the aircraft to yaw at the rotation.

From the start of the takeoff run until the 450-meter runway point, the aircraft moved along a straight line without any noticeable abnormality according to the images available, however, from that point on, at a speed of approximately 60kt, the aircraft veered off to the left, at an angle of 30º with the runway centerline. The analysis of the images did not allow confirming whether the left engine sustained loss of power. There was never an attempt by the pilot to apply the brakes or return the aircraft to the original take-off direction: the aircraft just kept oscillating vertically, sharply touching the ground several times.

The final speed of impact, despite the information provided by the transponder, was calculated based on the total distance traveled by the aircraft (693 meters) divided by the time of 18 seconds measured from the moment the aircraft veered off to the left, resulting an average speed of 75kt.

The intended rotation speed of the accident aircraft was 90kt so, considering the average speed, it’s possible that the rotation speed was not reached before the first impact.

Two main hypotheses, or even a combination of the three, can be raised from this information. The first hypothesis refers to excess weight, added to a possible wake turbulence generated by the preceding aircraft, preventing the departing aircraft from reaching the takeoff parameters. The second possibility suggests a loss of power of the left engine, considered critical for the aircraft.

The propellers of this aircraft rotate in the same direction (anti-clockwise, if one looks from the front), making the left engine the critical one in case of a sudden power failure or propeller overspeed.

Studies conducted by the Federal Aviation Administration (FAA), whose results are contained in a document called FAA's Accident Prevention Program FAA-E-8740-25, AFO-800-1079, concluded that, in case of failure of an engine of the BE58 aircraft, the loss in terms of performance would represent about 80.7%.

Based on these FAA studies, and considering the hypothesis of a possible engine failure, the aircraft would have difficulty reaching the rotation speed. Such condition, added to the 114.6kg excess weight, suggests that the pilot in command would not decide to proceed with the take-off, and, possibly, would only insist on taking off if lacking the slightest knowledge of the aircraft being flown.

The technical report issued by the DCTA on the analysis performed on both engines and respective propellers, makes it clear that the engines had no indication of technical discrepancies. However, the verification of marks left on the propellers after the impact with the ground, it became evident that the right engine was developing full power (the tips of the blades were bent forward), while the left engine, according to the same report, presented, suggesting rotation at reduced power.

Nevertheless, keeping the scope, and considering an analysis conducted by the very DCTA, the engineers responsible for the investigation suggested a possible difficulty of interpretation concerning the marks seen on the left propeller blades, since, depending on the moment of the initial impact of the left engine, the type of surface could generate non-standard marks different from those normally observed in such occurrences.

The investigation commission, taking into account the several contributing factors present in this occurrence, does not agree with the hypothesis raised by the DCTA, since the analysis of the video images shows that the initial impact of the aircraft and the propellers with the vegetation took place when the wings were level. Thus, the different aspects of the damage to the two engines suggest a differential of power between them. The right engine, with high power, sustained more severe damage and the marks were more pronounced, while the left engine presented a better aspect, despite the severity of the occurrence, indicative of engine failure at take-off instead of reduced power.

Upon analyzing the various factors contributing to this occurrence, one might consider that the extreme difficulty experienced by the pilot in his private life, in addition to his feeling of uncertainty regarding his keeping the job in the company, may have subtly diminished his capacity to concentrate on the air activity and, consequently, may have affected his performance as a pilot.

Upon analyzing the video of the accident, the investigation commission observed that the pilot did not make any attempts to resume the takeoff direction or apply the brakes, suggesting the possibility that he was not able to identify any contingent failure of the left engine, as well as perform any procedure to abort take-off or stop the aircraft before the end of taxiway Alpha.

An engine failure, in this type of aircraft, is critical, especially if the affected engine is the left one and is not immediately feathered, increasing drag and creating a tendency of an abrupt yaw.

According to reports of experienced pilots, the loss of power of the left engine at take-off is critical and requires proficiency in performing the prescribed procedures.

The application of the pedal to the same side of the good engine should have been done right away. Based on the total time elapsed from the veer-off to the moment of impact (approximately 18 seconds), the pilot's reaction proved not effective.

Such lack of action could be associated with two hypotheses: psychosocial factors experienced by the pilot would be leading him to an exaggerated concern with factors other than the flight itself, and making it difficult for him to maintain the focus on operational issues; and/or the lack of initial and recurrent training in the company may have hindered his understanding of the emergency, as well as his implementation of the appropriate operational actions required by the Aircraft Operating Manual.

Although the pilot was working as a freelancer on the accident flight, the aircraft belonged to the same owner of the air taxi company which had the pilot as one of its employees. Thus, if a systematic crew monitoring had existed in the company, the contingent vulnerabilities and sensitivities arising from the social environment and from the climate of instability at work (which were allegedly affecting the performance of the crew) could have been identified.

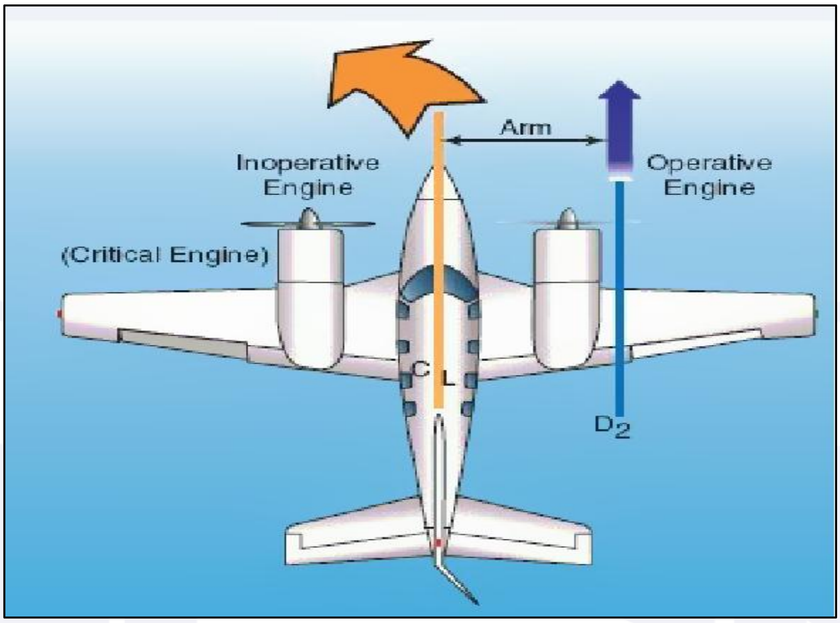

Figure 10 – Critical engine inoperative – Yaw tendency

The supposed left engine failure may also have been aggravated by the association of a possible lingering wake turbulence generated by the previous landing of an Airbus aircraft on the second one-third of the runway.

3. CONCLUSIONS.

3.1 Facts.

a) the pilot had a valid aeronautical medical certificate (CMA):

b) the pilot had a valid technical qualification certificate (CHT);

c) the pilot had qualification and enough experience in the model of aircraft;

d) the aircraft had a valid airworthiness certificate (CA);

e) the aircraft was not within the prescribed weight and balance limits;

f) the airframe, engine, and propeller logbooks had up-to-date records;

g) at the moment of take-off, the wind was calm, and the airport operation was normal;

h) at the moment of take-off, the aircraft had an excess weight of 114.6 kg;

i) the take-off run started approximately 1 minute and 15 seconds after the landing of an Airbus A320;

j) after traveling a distance of about 450 meters on the runway, the aircraft veered off to the left at an angle of 30º with the runway centerline;

k) the aircraft traveled a distance of about 690 meters before the first impact;

l) the final impact with the terrain occurred in a 10-meter deep terrain depression, next to taxiway Alpha

m) the aircraft exploded on account of the strong impact and quantity of remaining fuel;

n) the aircraft sustained substantial damage;

o) three passengers were taken to hospital, where they later died; and

p) the pilot and two of the passengers perished in the crash site.

3.2 Contributing factors.

- **Control skills – a contributor.**

No corrections were made during the occurrence of the abnormality, indicating a possibility that the pilot did not act on the flight controls in order to respond to the emergency during the take-off run.

- **Training – undetermined.**

The lack of initial and recurrent training in the company may have hampered the pilot's understanding of the emergency and his application of appropriate operational actions in accordance with the Aircraft Operating Manual.

- **Piloting judgment – undetermined.**

The pilot may have failed to judge adequately the possibility of wake turbulence generated by a MEDIUM size aircraft which landed one minute before he started the take-off run.

- **Perception – undetermined.**

It is possible that situations of personal and professional nature diminished the pilot's perception capability, and impaired his ability to recognize, organize and understand the environmental stimuli to which he was subjected in the occurrence.

- **Air Traffic planning (ATS) – undetermined.**

Although the separation between the landing and departing airplanes was provided in accordance with established rules, the fact that the A320 aircraft touched down on the second one-third of the runway may have created a wake turbulence that affected the take-off performance of the BE58 aircraft.

- **Flight planning – undetermined.**

The aircraft was refueled with more fuel than necessary, and had about 114 kg above the maximum take-off weight.

- **Decision-making process – undetermined.**

The accident data indicate that there was no proper assessment of the possibility of wake turbulence. The possible lack of knowledge or appreciation of aspects not relevant to the situation, may have led him to a reduction in his ability to understand and act appropriately in response to the situation.

- **Organizational processes – undetermined.**

The lack of a systematic monitoring of the crews in the company did not allow the identification of vulnerabilities and susceptibilities which were possibly affecting the crews' performance.

- **ATS publication – undetermined.**

The ICA 100-37 - Air Traffic Services only prescribes a 2-minute separation between a MEDIUM size landing aircraft and a LIGHT departing aircraft if the threshold has been displaced, without considering that an aircraft may touch down on the runway at a more advanced position, causing the same wake turbulence effects of displaced thresholds.

4. SAFETY RECOMMENDATION.

A measure of preventative/corrective nature issued by a SIPAER Investigation Authority or by a SIPAER-Link within respective area of jurisdiction, aimed at eliminating or mitigating the risk brought about by either a latent condition or an active failure. It results from the investigation of an aeronautical occurrence or from a preventative action, and shall never be used for purposes of blame presumption or apportion of civil, criminal, or administrative liability.

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 Airspace Control Department – DECEA:

A-131/CENIPA/2015 – 01 **Issued on 22/04/2016**

Emphasize the need to report the possible existence of wake turbulence during aircraft landings and take-offs, aiming at alerting the crews in relation to the time-separation prescribed in the ICA 100-37 – Air Traffic Services..

5. CORRECTIVE OR PREVENTATIVE ACTION ALREADY TAKEN.

None.

On April 22th 2016.