COMANDO DA AERONÁUTICA

CENTRO DE INVESTIGAÇÃO E PREVENÇÃO DE ACIDENTES AERONÁUTICOS

FINAL REPORT
A - 512/CENIPA/2016

OCCURRENCE:	**ACCIDENT**
AIRCRAFT:	**PR-PSJ**
MODEL:	**EMB-145LU**
DATE:	**25 AUG 2010**

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 25 August 2010 accident with the EMB-145LU aircraft, registration PR-PSJ. The accident was classified as “runway undershoot”.

On the final approach of a VFR procedure for landing on the runway 15, the aircraft main landing gear and the underside of the fuselage hit a small mound located in the undershoot area of the runway.

The aircraft skidded for 300 meters and ran off the runway via the left side.

The aircraft sustained substantial damage.

None of the aircraft occupants was injured.

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

CONTENTS

GLOSSARY OF TECHNICAL TERMS AND ABBREVIATIONS

ANAC	Brazil's National Civil Aviation Agency
ATP	Airline Transport Pilot - airplane category
ATS	Air Traffic Services
CENIPA	Aeronautical Accident Investigation and Prevention Center
CIV	Pilot's Flight Logbook
CRM	Crew Resource Management
CVR	Cockpit Voice Recorder
FDR	Flight Data Recorder
GSO	Operational Safety Manager
IFR	Instrument Flight Rules
INFRAERO	Brazilian Airports Infrastructure Enterprise
Lat	Latitude
Long	Longitude
METAR	Aerodrome Routine Weather Report
MGSO	Operational Safety Management Manual
NTSB	National Transportation Safety Board (USA)
PAPI	Precision Approach Path Indicator
PCM	Commercial Pilot - airplane category
PPR	Private Pilot - airplane category
RBAC	Brazilian Federal Aviation Rules
RS	Safety Recommendation
SBGR	ICAO location designator - Guarulhos International Airport
SBQV	ICAO location designator - Vitória da Conquista Airport
SIPAER	Aeronautical Accident Investigation and Prevention System
TPR	Regular Public Air Transport Service
UTC	Universal Time Coordinated
V_{AP}	Approach Speed
VASIS	Visual Approach Slope Indicator System
VFR	Visual Flight Rules
V_{REF}	Minimum Final Approach Speed

1. FACTUAL INFORMATION.

Aircraft	**Model:** EMB-145LU **Registration:** PR-PSJ **Manufacturer:** EMBRAER	**Operator:** *Passaredo Linhas Aéreas*.
Occurrence	**Date/time:** 25AUG2010 / 17:40 UTC **Location:** SBQV **Lat.** 14°51'49"S **Long.** 040°51'47"W **Municipality – State:** *Vitória da Conquista* - State of Bahia.	**Type(s):** Landing short of the runway

1.1 History of the flight.

The aircraft took off from the *André Franco Montoro* International Airport (SBGR) in the municipality of *Guarulhos*, State of São Paulo, destined for *Vitória da Conquista* Airport (SBQV), on a regular passenger transport flight, with three crewmembers and thirty-five passengers on board.

On the final segment of a VFR approach to runway 15 of SBQV, the main landing gear and the underside of the aircraft hit a small mound located short of the runway threshold.

The aircraft skidded for 300 meters and ended up exiting the runway via its left side. It came to rest at approximately 35 meters from the runway.

The aircraft sustained substantial damage.

After the aircraft stopped, all the passengers evacuated the aircraft under the coordination of the crew.

1.2 Injuries to persons.

Injuries	Crew	Passengers	Others
Fatal	-	-	-
Serious	-	-	-
Minor	-	-	-
None	3	35	-

1.3 Damage to the aircraft.

The aircraft sustained substantial damage to the engines, landing gear, fuselage, and horizontal stabilizer.

Figure 1 - Aircraft final position.

1.4 Other damage.

None.

1.5 Personnel information.

1.5.1 Crew's flight experience.

Hours Flown		
	Pilot	Copilot
Total	4.400:00	1.373:50
Total in the last 30 days	77:50	47:50
Total in the last 24 hours	02:37	03:05
In this type of aircraft	3.100:00	813:58
In this type in the last 30 days	77:50	47:50
In this type in the last 24 hours	02:37	03:05

N.B.: Data obtained from the pilot's flight logbooks

1.5.2 Personnel training.

The pilot took his Private Pilot course (airplane category) at the *São Leopoldo* Flying School in 1986.

The copilot took his Private Pilot course (airplane category) at the *Londrina* Flying School in 2003.

1.5.3 Category of licenses and validity of certificates.

The pilot held an ATP license (airplane category), as well as valid E145LU and IFR ratings.

The copilot held a Commercial Pilot license (airplane category), as well as valid E145 aircraft technical qualification certificates and IFR-rating

1.5.4 Qualification and flight experience.

Both pilots had qualification and enough experience for the flight in question.

1.5.5 Validity of medical certificate.

The pilots held valid Aeronautical Medical Certificates.

1.6 Aircraft information.

The aircraft (SN145351) was manufactured by EMBRAER in the year 2000, and was registered in the Regular Public Air Transport Service category.

Its airworthiness certificate was valid.

The records of its airframe and engine logbooks were up-to-date.

The last inspection of the aircraft ("Routine" type) was done by the *Passaredo* Workshop on 20 August 2010. The aircraft flew 57 hours and 47 minutes after the inspection.

The last overhaul of the aircraft was done by the OGMA Workshop on 21 June 2010. The aircraft flew 387 hours and 15 minutes after the overhaul.

1.7 Meteorological information.

The prevailing weather conditions VMC, as shown in the METAR reports below:

SBQV 251700Z 09011KT 9999 FEW010 BKN015 23/18 Q1022=

SBQV 251800Z 08015KT 9999 SCT015 22/17 Q1021=.

1.8 Aids to navigation.

Nil.

1.9 Communications.

The Cockpit Voice Recorder (CVR) showed that the crew maintained full two-way radio contact with ATC, with the communications equipment operating uneventfully during the whole flight.

1.10 Aerodrome information.

SBQV was a public aerodrome under the administration of the Bahia State Government. It operates VFR/IFR during day- and night-time.

It had an asphalt-paved runway, measuring 1,775m x 30m, with thresholds 15/33, at an elevation of 3,002 ft.

The runway, in the direction 15/33 had a pronounced acclivity starting on the threshold 15 with an extension of approximately 1,000 meters, followed by a stretch of level ground, and then a declivity which extends as far as the threshold 33.

1.11 Flight recorders.

The Flight Data Recorder (FDR) recordings showed that all systems were working properly in the moments preceding the impact.

The CVR read-out revealed that the pilot was adjusting the aircraft to land and, moments before the impact, reported difficulty to pitch up the aircraft in order to correct a low approach slope.

1.12 Wreckage and impact information.

The landing gear and underside of the aircraft hit a small mound that had been built in the undershoot area for the containment of rain water.

After the impact with the mound, the aircraft bounced before touching the ground again (on the runway) with the underside. It kept moving ahead for about 180 meters until exiting the runway via the left side. Then it continued moving for more than 130 meters on a grass area outside of the runway.

The aircraft collided with two of the three sets of VASIS back lights, and then came to a stop at a distance of 35 meters to the left of the runway.

The main landing gear collapsed, and there was substantial damage to the aircraft fuselage and wings.

1.13 Medical and pathological information.

1.13.1 Medical aspects.

According to the pilots, that had been the first time they operated in SBQV.

Based on the CVR recordings, the investigating committee verified that the pilots, had difficulty identifying the runway during the VFR approach. The crew also made comments on the presence of lots of vultures in the region.

The aerodrome characteristics, as a matter of fact, could lead the pilots to an ambiguous interpretation of the approach slope.

The level of the terrain near the threshold is lower than the level of the threshold, and may create the illusion that the aircraft is a position that is higher than the one the crew is used to.

In addition, the runway in SBQV was narrower than most runways where the crew usually operated. It had a width of 30 meters, while the runways of Guarulhos, Ribeirão Preto, and Ilhéus, were 45 meters wide.

Such characteristic of a narrower runway may lead the crew to a visual illusion while they are on the approach for landing. Pilots develop a mental model of the runway size, and compare it with the size of the runway in sight at the moment of landing.

Thus, for the crew, a narrower runway would look as if it were a 45m-wide runway seen from a higher position. Such illusion leads the crew to “correcting” the altitude for an approach slope that, in reality, is lower than the 3º-standard. Figure 2 shows the effect of runway width on the pilot’s perception.

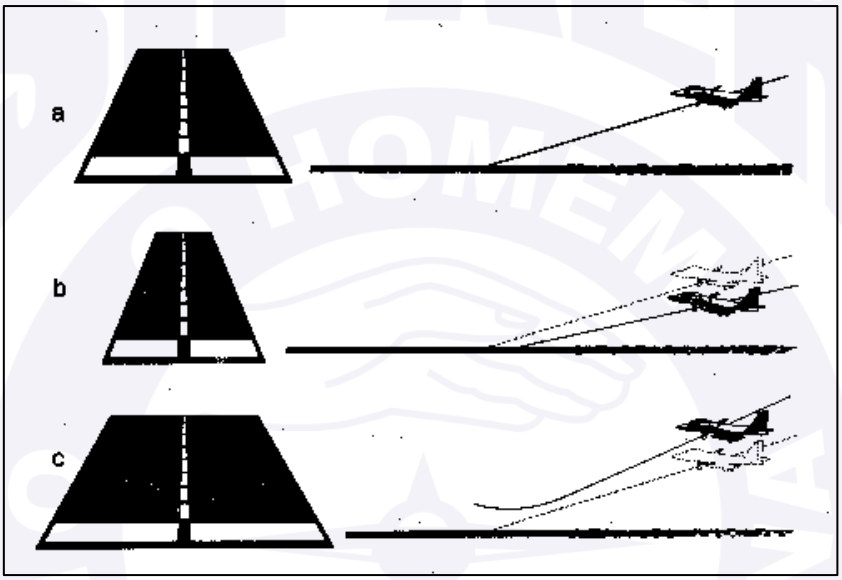

Figure 2 - Comparison of the crew’s sighting of the runway with their respective position in relation to the ideal approach slope, considering different runway widths.

Figure 2 shows the image of a runway with “normal” width (which, for most of the company pilots, would be 45 meters), as seen by the pilots from the cockpit, forming the trapezoidal shape observed in letter “a”. In figure “b”, the runway is narrower, creating in the crew the illusion that they are flying along a higher approach slope, and a tendency to “correct” to a lower one. Letter “c” shows an approach to a wider-than-normal runway, which would create the opposite effect, that is, the crew would have the illusion of low approach, and would have the tendency to “correct” to a higher approach.

Another aspect worth pointing out is that the runway 15 in SBQV presented a pronounced acclivity approximately 1,000 meters long, as measured from the threshold in the direction of the departure end.

Figure 3 - Final approach to runway 15. (the arrow indicates the position where the aircraft came to a stop).

In Figure 4, it is possible to relate the crew's sighting of the runway to the corresponding position of the aircraft in relation to the ideal approach slope for runways with different types of gradient. Letter "a" shows a level runway as seen by the pilot from the cockpit, with the aircraft stabilized on the ideal approach slope; letter "b" depicts a runway with an acclivity, leading the crew to the illusion that they would be flying above the ideal approach slope; and letter "c" shows the approach to a runway having a declivity, creating in the crew the illusion that they would be making a low approach, leading them to "correct" toward a higher approach.

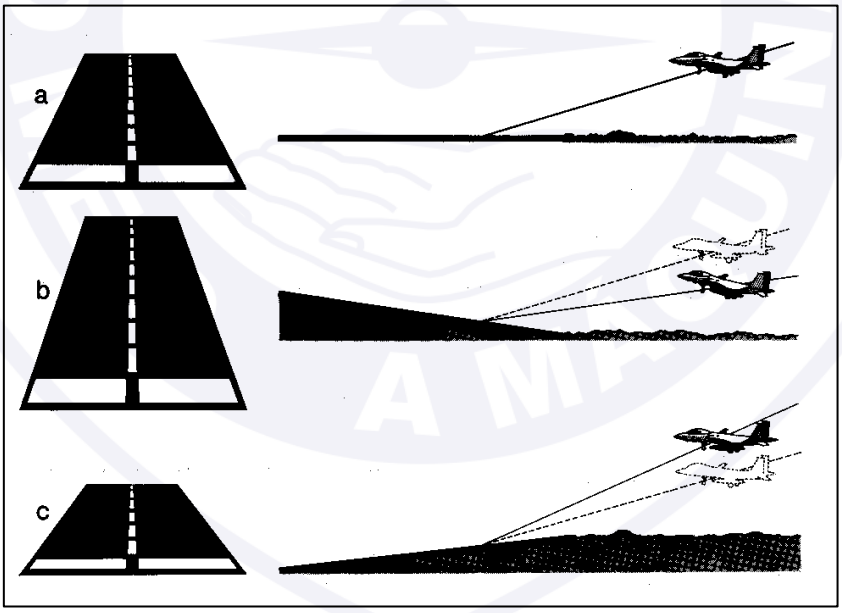

Figure 4 - Different runway slopes and position of the aircraft relative to the ideal approach slope.

Such characteristic of the SBQV runway could lead the pilots to mistakenly believe that the aircraft was above the ideal approach slope, even though it was at the correct altitude. Thus, the pilots would have the tendency to "correct" the aircraft toward a smaller angle of approach. To avoid being deceived by the illusion, they would have to pay close

attention to the visual-approach aids, work with each other in a coordinated manner (CRM) in the cockpit, as well as study the aerodrome characteristics in advance.

The pilot, upon making a correct approach to a runway with which is familiar, stores in his/her mind an ideal trapezoidal image, which indicates accurately the angle of a correct approach slope. Therefore, in SBQV, the pilot would seek to obtain this ideal image of the runway, by making a lower approach, should he not be using the VASIS as a reference.

1.13.2 Ergonomic information.

Nil.

1.13.3 Psychological aspects.

The aircraft captain, who was also a flight instructor, had already operated in other countries, working as a test pilot for two years. His experience included another two years as an agricultural pilot, and 14 years as a pilot for Rio Sul Airlines.

He reported not being tired, since he had had a two-day period of rest before the accident flight. He went to bed early the day before, and was not taking any medication.

That was his first flight in that region and the weather conditions were VMC. He also said that at the end of the approach, the presence of numerous birds caught his attention.

His operational routine would normally include determining in advance (at the briefing) which crewmember would be responsible either for the landing or for the takeoff. If one was to make the landing, the other one would make the takeoff. Such agreement was usually applied in the company.

The captain informed that he and the copilot decided to make a visual approach in order to get more familiarized with the relief of the terrain. He said that the variations of the relief could affect their perception of height, and might cause confusion during the approach.

He did not have a clear recollection of everything that was said in the cockpit, but remembered having commented with the copilot that they were low in the hope this latter did something about it. As for himself, he did not react toward correcting the approach.

He reported that he was living a peaceful period of his life, and was happy with his work at the company. He was glad for living in the same city where the company had its headquarters, because this facilitated his family interaction.

During the accident flight, He felt being in a “comfort zone” on account of his experience in the aircraft, the fact that he had a dependable copilot, and the fact that the flight was proceeding uneventfully. According to the captain, these facts made him feel relaxed, and, therefore, his attention was not drawn to the operation in a new locality.

The copilot graduated in Aeronautical Sciences in 2007, and before being hired by *Passaredo*, he worked for a year and a half as a pilot of the executive aviation.

Before the day of the occurrence, he had had a three-day rest period. During the briefing for the flight, it was agreed that he would be responsible for the first leg of the flight. It was the first time he flew to SBQV.

The copilot said that when he observed the indication that they were below the glide path, he commented it with the captain, who told him to raise the “nose” of the aircraft. However, he considered that the captain was not emphatic enough to make him aware of the need a more effective correction.

The captain, in turn, said that although he considered the glide path to be low, the situation did not worry him to the point of leading him to request a correction of the aircraft trajectory.

According to them (captain and copilot), the company pilots had the custom of performing lower glide paths, independently of where they could be operating, since they utilized aircraft without reverse thrust.

The copilot also informed that the position of the sun was making it difficult sighting the runway, and he asked the captain whether that was really the runway of SBQV.

In addition, he said that the presence of birds on the final approach drew his attention for a few moments in detriment of the operation.

He also reported counting on the captain to assist him during the approach, and that he saw the red lights of the VASIS but had the impression of being on the correct approach slope.

In a joint interview, both the captain and the copilot reported that topics of CRM were addressed at the briefing of the flight, such as communication between the pilots and the purser, fuel, timetable, and IFR approach. No specific comment was made regarding the aerodrome characteristics.

For the captain, the copilot was a calm person, with whom he liked to fly. The copilot, in turn, said that he felt comfortable flying with the captain, and had confidence in his experience and guidance. The purser ratified these characteristics of the cockpit crew.

As for the operation in SBQV, there were neither warnings nor information issued by the company in relation to the runway, which had characteristics of a pronounced acclivity.

The pilots had been hired by the company less than a year before. They had proper qualification, in accordance with the company's training program.

1.14 Fire.

After the first impact, the main landing gears broke, and hit the aircraft engines.

The right engine caught fire due to the rupture of a fuel line. The fire was extinguished by the aerodrome firefighters after the aircraft stopped.

1.15 Survival aspects.

After the aircraft stopped, the passengers were evacuated through its main door. None of the passengers and crew members was injured.

1.16 Tests and research.

Nil.

1.17 Organizational and management information.

The flight-safety structure of the company consisted of only one person, who, in addition to being responsible for the area of safety, also composed the crew of regular flight schedules.

In relation to the operation in SBQV, no study regarding risk management was presented.

From what the investigating committee could observe, this kind of practice was not adopted by the company for the evaluation of the risks associated with operations in new places.

1.18 Operational information.

Neither pilot had landed in SBQV before. The aerodrome had physical characteristics different from those commonly dealt with, with a runway which was narrower and which had a pronounced acclivity (RWY 15).

The weather was VMC throughout the flight. Approaching the destination, the crew chose to cancel the IFR flight plan and fly VFR in order to get acquainted with the topography of the region. The aircraft FDR recorded an extension of the downwind leg and the start of the descent beyond the normal position, at a greater distance from the threshold, resulting in a lower approach slope.

The aircraft weight and center of gravity limits were within the limits specified by the manufacturer.

According to the FMS data, which were commented in flight by the crew, the aircraft had an estimated weight of 17,500 kg. The altitude of the runway in SBQV was 3,002 ft. The wind reported by the local AFIS was 140º at 10 kt.

After inserting these data in a table of unfactored landing distance, one obtains a required landing distance of 811 meters. Such distance specified by the aircraft manufacturer did not consider the utilization of the reverse thrust, and was established for the aircraft passing over the runway threshold at a height of 50 ft, at the $V_{REF,}$ and touching down at the 1,000 ft mark (approximately 300 meters past the runway threshold).

UNFACTORED LANDING DISTANCE

UNFACTORED LANDING DISTANCE (METERS) – DRY RUNWAY
EMB-145 - FLAPS 45°
ISA CONDITIONS - SLOPE 0%

WEIGHT (kg)	ALTITUDE							
	0 ft				1000 ft			
	WIND				WIND			
	-10 kt	0 kt	10 kt	20 kt	-10 kt	0 kt	10 kt	20 kt
20000	1007	864	819	776	1029	884	839	795
19000	971	831	788	745	992	851	806	763
18000	935	799	757	715	955	817	774	732
17000	902	769	727	687	920	786	743	702
16000	868	738	697	658	885	754	713	673
15000	832	705	666	627	848	720	680	641
14000	794	671	633	595	810	685	646	608
13000	756	637	599	563	770	650	612	575
12000	717	602	565	530	731	614	577	542

WEIGHT (kg)	ALTITUDE							
	2000 ft				3000 ft			
	WIND				WIND			
	-10 kt	0 kt	10 kt	20 kt	-10 kt	0 kt	10 kt	20 kt
20000	1053	906	859	815	1077	927	881	835
19000	1014	871	826	782	1037	891	846	802
18000	976	836	792	749	998	856	811	768
17000	940	803	760	719	959	821	778	735
16000	904	770	729	688	922	788	745	704
15000	866	736	695	656	884	752	711	671
14000	826	700	661	622	843	716	676	637
13000	786	664	626	588	802	678	640	602
12000	745	627	590	554	760	640	603	566

Figure 5 - EMB145 landing performance data.

Considering the operation under the RBAC 121, which required the aircraft to land at the destination airport making use of 60% of the effective runway length, the crew had 1,065 meters for landing. Such landing distance was sufficient for a safe operation of the EMB145 aircraft in SBQV, whose runway had a total length of 1,775 meters.

The aircraft manufacturer's manual states that the pilots are supposed to be on a stabilized approach (on course, on glide path, at the selected speed, and at landing configuration) on a 3-mile final. The stabilized final approach is to be maintained in order to allow more precision at landing. Otherwise, the crew runs the risk of having to resort to either excessive sink-rates or to excessive "fluctuation" (during the flare) for touching down on the runway.

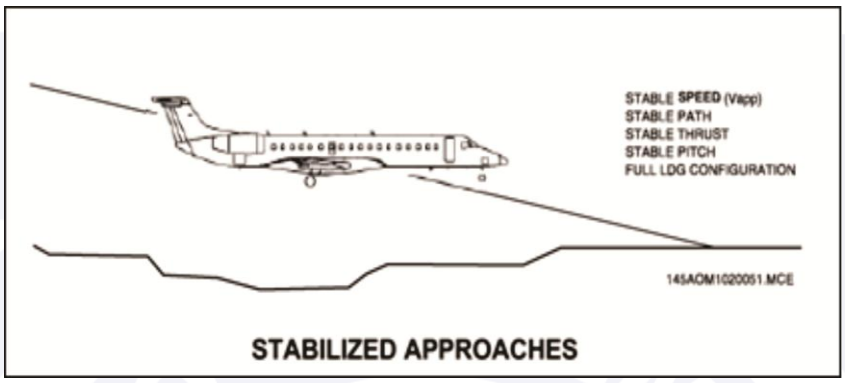

Figure 6 - Illustration of a stabilized final according to the manufacturer's manual.

The copilot (at the aircraft controls) disengaged the autopilot at an altitude of 800 ft AGL, and maintained a glide path below the standard 3º during the approach, while observing, together with the captain, nearby obstacles. The flaps were extended to 45º at the altitude of 250 ft AGL at a distance of about 2 nautical miles to the runway.

For a weight of 17,500 kg, the calculated V_{REF} was 124 kt, and the calculated approach speed (V_{AP}) was 129 kt. The speed of the aircraft varied around 137 kt, with its flaps positioned at 45º, until the moment of the impact. The copilot told the captain that he was aware of the speed.

Six seconds before the impact, the copilot reported the VASIS was red, an indication that they were below the prescribed glide path. Two seconds before the impact, the captain even told the copilot to raise the "nose" of the aircraft in order to correct the glide path, but there was not enough time for the copilot to do so.

Although the copilot reported that a given moment he had noticed that the aircraft was below the ideal glide path and that he had attempted to make a correction, the FDR data showed that no effective correction was made.

Moments before the impact, according to the CVR recording, the copilot showed that he could not understand why the VASIS lights were still red, despite his correction efforts.

1.19 Additional information.

Nil.

1.20 Useful or effective investigation techniques.

Nil.

2. ANALYSIS.

The first aspect of the occurrence to be analyzed was the fact that the crew had qualification for the flight in question, their training was up-to-date, and the captain was rather experienced in the aircraft model (with more than 3,000 flight hours).

Comparatively, the copilot's experience was shorter, but his more than 800 hours of flight in the model were an indication that he had the ability of evaluating the aircraft performance in the various phases of flight.

Thus, the fact that an experienced crew was not able to prevent the aircraft from colliding with an obstacle in the undershoot sector led the investigating committee to questioning whether a technical discrepancy of the aircraft might have contributed to the outcome of the event.

Initially, the analysis focused on contingent aircraft problems capable of hindering an effective recovery from a low approach.

Upon examining the data recorded by the FDR, the investigating committee verified that the engines had responded accordingly to the crew's inputs until the moment of the impact.

The committee also verified that there was no technical discrepancy in the navigation systems, flight controls, or equipment utilized for the approach. Thus, the focus of the analysis was directed to the operational issue.

During the whole final approach, only once did the copilot mention that the approach was being made with red VASIS lights, an indication that the aircraft was below the standard glide path (which was 3º for the runway in question).

In addition to the fact that the aircraft was below the ideal glide path, it was observed that the aircraft speed was 8 kt above the V_{AP}, the flaps were extended to the position required for landing (45º) at 250ft AGL at a distance of 2 nautical miles to the runway threshold, in disagreement with the manufacturer's recommendations for a stabilized approach, which could have increased the probability of a safe landing.

It took long for the copilot to communicate his difficulty correcting the approach slope, and when he did it, he was not sufficiently assertive to draw the captain's attention to the situation.

Some of the aspects observed in the context of the occurrence may have contributed to a failure of the perceptive process:

- the attention of the crew being turned away from the glide path parameters in order to focus on obstacles close to the approach course of the runway 15;

- the characteristics of the runway and surrounding terrain, which may have induced an optical illusion in the crew when they aligned with the runway; and

- the culture of the company pilots, who had the custom of approaching the runway below the standard glide path, believing that, by doing so, they would decrease the distance required for landing, since their aircraft was not equipped with thrust-reversers.

Thus, the aircraft was flown along a lower approach slope (red VASIS lights) taking the runway aspect (as perceived by the pilots from the cockpit) as the only reference for landing.

Taking into account that the pilots had never operated in that aerodrome, and that the company had never issued any warnings with regard to the runway characteristics, there was a poor crew's situational awareness in relation to the special care to be taken for the operation in SBQV.

Since a more effective action was never taken in flight for correcting the lower approach slope, the idea of a visual illusion on the part of the captain is reinforced.

A significant number of visual illusions may occur during the approach, and the means available for preventing their occurrence are training, application of CRM, and use of approach aids (navigation aids and visual approach slope indicators - VASIS and PAPI).

The occurrence in question may have been the result of a poor flight planning, since, from what could be observed in the interviews, there was not concern in the pre-flight briefing, besides the fact that the very company did not publish warnings related to the specific characteristics of SBQV.

It is worth pointing out that there was inadequate management on the part of the company, since it failed to identify the risks inherent to the operation in that location and, consequently, did not publish any alerts to assist the pilots.

At the time of the occurrence, the company flight-safety sector consisted of just one person, who also had to meet the demands of the flight schedule, something not desirable for a company of that size, since a deficient number of qualified personnel in the area of flight safety will necessarily result in poor management of the potential risks present in the operation of the airline.

3. CONCLUSIONS.

3.1 Facts.

a) The pilots had valid Aeronautical Medical Certificates;

b) The pilot had valid type ratings;

c) The pilots had qualification and enough experience for the type of flight;

d) The pilots' qualification was in accordance with the company's training program;

e) The aircraft had a valid airworthiness certificate;

f) The aircraft was within the prescribed weight and balance limits;

g) The records of the airframe and engine logbooks were up-to-date;

h) There was no discrepancy of technical nature that might have affected the aircraft performance in the moments preceding the impact;

i) That was the first time the pilots were making an approach to the locality of Vitória da Conquista (SBQV);

j) At the moment of the accident, the aerodrome was open for VFR operations;

k) The crew decided to cancel the IFR approach to make a VFR approach;

l) The runway 15 of SBQV had a pronounced acclivity in its first two-thirds;

m) The runway in SBQV was 30 meters wide, narrower than the ones on which the crew used to operate, with a width of 45 meters;

n) In the company, there was a culture of maintaining an approach slope below the ideal one for runways considered shorter;

o) On the approach, the crew's attention was drawn to obstacles and birds on the final of runway 15;

p) The main landing gear of the aircraft touched the ground short of the threshold of runway 15;

q) The aircraft sustained substantial damage;

r) The passengers were evacuated through the main door of the aircraft; and

s) None of the aircraft occupants was injured.

3.2 Contributing factors.

- **Attention - a contributor.**

During the approach, the flight crew 's attention was focused on the characteristics of the geographical relief and presence of birds, reducing their awareness as to the maintenance of the approach slope.

- **Work-group culture - a contributor.**

The group culture of maintaining a low angle of approach led the crew to choose the runway aspect instead of the VASIS as a reference for the approach, making them susceptible to various types of spatial illusion.

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

Taking into account copilot's report that he was not succeeding in correcting the aircraft glide path relative to the runway, one may suppose that he was not applying the appropriate amplitude for such correction.

- **Visual illusions - a contributor.**

The physical characteristics of the runway 15 (the active one) contributed to a wrong perception of the ideal glide path. The pronounced acclivity of the runway, its width (narrower than the runways on which the crew was accustomed to operate), and the low terrain near the threshold, caused in the pilots a perception that they were above the ideal approach slope, leading them to seek correction, which resulted in an angle of approach below the ideal one.

- **Management planning - undetermined.**

For the flight in question, the company chose two pilots who had never operated in SBQV. A crewmember with previous experience in the locality would have a higher level of awareness in relation to the specific characteristics of the aerodrome.

- **Support systems - a contributor.**

No company publications were found that could provide the pilots with guidance on the specifics of SBQV, capable of helping with the management of the risks associated with the operation in that aerodrome.

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 National Civil Aviation Agency (ANAC):

A-512/CENIPA/2016 - 01 Issued on 26/05/2017

Take the necessary measures before *Passaredo Linhas Aéreas*, in order to guarantee company's adoption of risk assessment mechanisms for new operations, with subsequent issuance of mitigating measures to ensure operation within acceptable margins of risk.

A-512/CENIPA/2016 - 02 Issued on 26/05/2017

Take the necessary measures before *Passaredo Linhas Aéreas,* in order to guarantee that the training delivered by the company includes the transmission of knowledge on how to identify visual illusions, and also that their crews be alerted when a locality susceptible to the occurrence of such phenomenon is identified.

A-512/CENIPA/2016 - 03 Issued on 26/05/2017

Take the necessary measures before *Passaredo Linhas Aéreas*, in order to guarantee the adoption of procedures for the identification of possible deficiencies in the professional formation of its pilots, such as on how to interpret and utilize landing aid systems (VASIS, PAPI, etc.).

5. CORRECTIVE OR PREVENTATIVE ACTION ALREADY TAKEN.

As soon as some of the contributing factors were determined, a meeting was held with the President, Director of Operations, and Operational Safety Manager of *Passaredo Linhas Aéreas* for comments, with proper recommendations aimed at preventing their recurrence.

A Special Flight-Safety Inspection revealed unsafe conditions associated with the accident and other areas, and mitigating actions were recommended to correct them.

On May 26th, 2017.