COMANDO DA AERONÁUTICA

CENTRO DE INVESTIGAÇÃO E PREVENÇÃO DE ACIDENTES AERONÁUTICOS

FINAL REPORT
A - 005/CENIPA/2016

OCCURRENCE:	**ACCIDENT**
AIRCRAFT:	**PR-PDD**
MODEL:	**ATR-72-212A**
DATE:	**09JAN2016**

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 09JAN2016 accident with the ATR-72-212A aircraft model, registration PR-PDD. The accident was classified as “[USOS] Undershoot/Overshoot”.

During approach for visual landing, at night, at the Maestro Marinho Franco Aerodrome (SBRD), Rondonópolis - MT, the crewmembers performed the final approach keeping an approach ramp lower than the ideal and, when they realized the situation, they started a go-around procedure in the air, 20ft high.

During the go-around procedure, the aircraft continued to descend and touched the ground in a soybean plantation, about 400m before the runway threshold. The plane traveled a distance of approximately 72m on the ground before taking off again. In that distance, the aircraft collided with two concrete fence posts.

After leaving the ground, the pilots repositioned the aircraft for landing in the direction of runway 20, opposite to that used initially (runway 02).

The second landing attempt was made without major complications.

The aircraft had substantial damage.

All the occupants left unharmed.

An Accredited Representative of the Bureau d'Enquêtes et d'Analyses pour la Sécurité de l'Aviation Civile (BEA) - France (State where the aircraft was designed and manufactured) was designated for participation in the investigation.

CONTENTS

GLOSSARY OF TECHNICAL TERMS AND ABBREVIATIONS

AC	Advisory Circular
AFIS	Aerodrome Flight Information Service
ALAR	Approach-and-Landing Accident Reduction
ALS	Approach Lighting System
APO	Provisional Operation Authorization
ATS	Air Traffic Services
BEA	Bureau d'Enquêtes et d'Analyses pour la Sécurité de l'Aviation Civile
CA	Airworthiness Certificate
CET	Technical-Operational Specialization Certificate
CENIPA	Aeronautical Accident Investigation and Prevention Center
CINDACTA	Air Defense and Air Traffic Control Integrated Center
CIV	Pilot's Flight Logbook
CM	Registration Certificate
CMA	Aeronautical Medical Certificate
COMAER	Aeronautics Command
CVR	Cockpit Voice Recorder
DECEA	Air Space Control Department
EPTA	Telecommunications and Air Traffic Service Provider Station
FAP	Pilot's Evaluation Sheet
FCOM	Flight Crew Operations Manual
FDR	Flight Data Recorder
FI	Flight Idle
FL	Flight Level
FSF	Flight Safety Foundation
ICA	Aeronautics Command Instruction
IFR	Instrument Flight Rules
IFRA	Instrument Flight Rating - Airplane
LABDATA	Flight Data Recorders Read-Out and Analysis Laboratory
MGO	General Operations Manual
METAR	Aviation Routine Weather Report
OEA	Aeronautical Station Operator
PAPI	Precision Approach Path Indicator
PLA	Airline Pilot License - Airplane
PN	Part Number
PPR	Private Pilot License – Airplane
QNH	Pressure reduced at sea level by the vertical gradient of the standard atmosphere

SBBR	ICAO Location Designator - Presidente Juscelino Kubitschek International Airport, Brasília - DF
SBGR	ICAO Location Designator - Governador André Franco Montoro Aerodrome, São Paulo - SP
SBRD	ICAO Location Designator - Maestro Marinho Franco Aerodrome, Rondonópolis - MT
SOP	Standard Operating Procedures
SPECI	Selected Special Aeronautical Weather Report
TLA	Thrust Lever Angle
UTC	Universal Time Coordinated
VASIS	Visual Approach Slope Indicator System

1. FACTUAL INFORMATION.

Aircraft	**Model:** ATR-72-212A **Registration:** PR-PDD **Manufacturer:** ATR – GIE *Avions de Transport Régional*	**Operator:** *Passaredo Transp. Aéreos* S.A
Occurrence	**Date/time:** 09JAN2016 - 0215 UTC **Location:** Maestro Marinho Franco Aerodrome (SBRD) **Lat.** 16°35'07"S **Long.** 054°43'27"W **Municipality – State:** Rondonópolis – MT	**Type(s):** [USOS] Undershoot/Overshoot **Subtype(s):** Undershoot

1.1 History of the flight.

The aircraft took off from the Presidente Juscelino Kubitschek Aerodrome (SBBR), Brasília - DF, to the Maestro Marinho Franco Aerodrome (SBRD), Rondonópolis - MT, at 0033 (UTC), in order to transport personnel, with 4 crewmembers and 54 passengers aboard.

The phases of takeoff, climb, flight at cruising altitude and descent went normally.

The crewmembers performed a night visual approach procedure for threshold 02 of the SBRD runway. During the procedure, the pilots crossed the Aerodrome, vertically from the center of the runway, starting a standard traffic circuit, with turns on the left.

The aircraft was initially high on the flight path and used a vertical speed of -900ft/min to reach the 3° flight path. The value was not adjusted afterward hence the aircraft went below the nominal 3° flight path.

The pilots realized that they were below the ideal ramp when the aircraft reached 50ft of altitude in relation to the terrain and started a go-around procedure at 20ft. Maximum power was selected 2sec later.

During the go-around procedure, the aircraft continued to descend and touched the ground in a soybean plantation, at a point located approximately 400m before threshold 02.

The plane traveled about 72m on the ground before taking off again, colliding with two concrete posts that supported the Aerodrome's patrimony fence.

After completing the go-around procedure, the crewmembers repositioned the plane for landing in the direction of runway 20, contrary to the first approach.

The second landing attempt took place without additional abnormalities.

The aircraft had damage to the front fuselage, radome, main and nose landing gear, as well as its doors.

All occupants left unharmed.

1.2 Injuries to persons.

Injuries	Crew	Passengers	Others
Fatal	-	-	-
Serious	-	-	-
Minor	-	-	-
None	4	54	-

1.3 Damage to the aircraft.

The damage found affected structural parts of the aircraft (Figures 1, 2 and 3) and, therefore, they were considered substantial.

Figure 1 - Left side view of the aircraft (Source: ATR).

Figure 2 - Right side view of the aircraft (Source: ATR).

The following damage occurred:

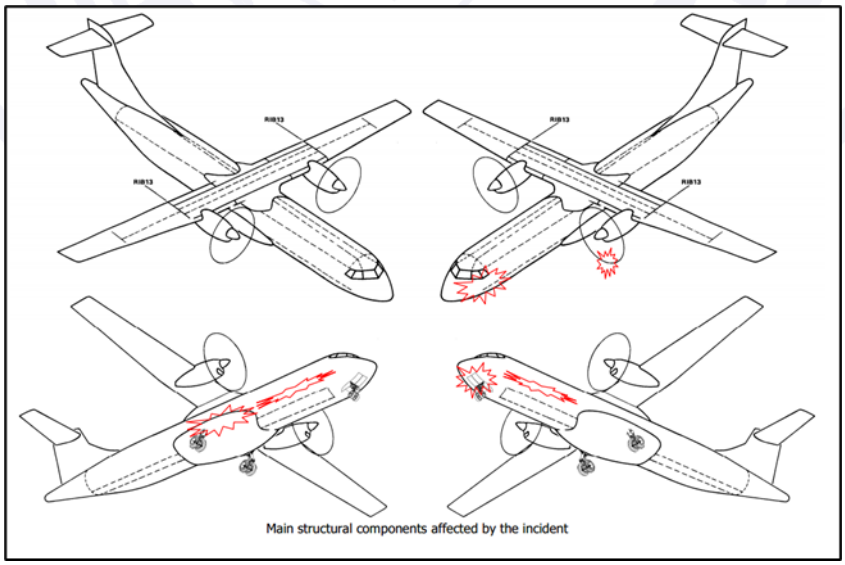


Figure 3 - Schematic view of the damage (Source: ATR).

Figure 4 - Perforations in the left front Skin Panel (Source: ATR).

Figure 5 - Perforations in the left front Skin Panel (Source: ATR).

The aircraft had damage in the lower section of frames 5 to 10 (Figures 6, 7, 8, 9, 10 and 11).

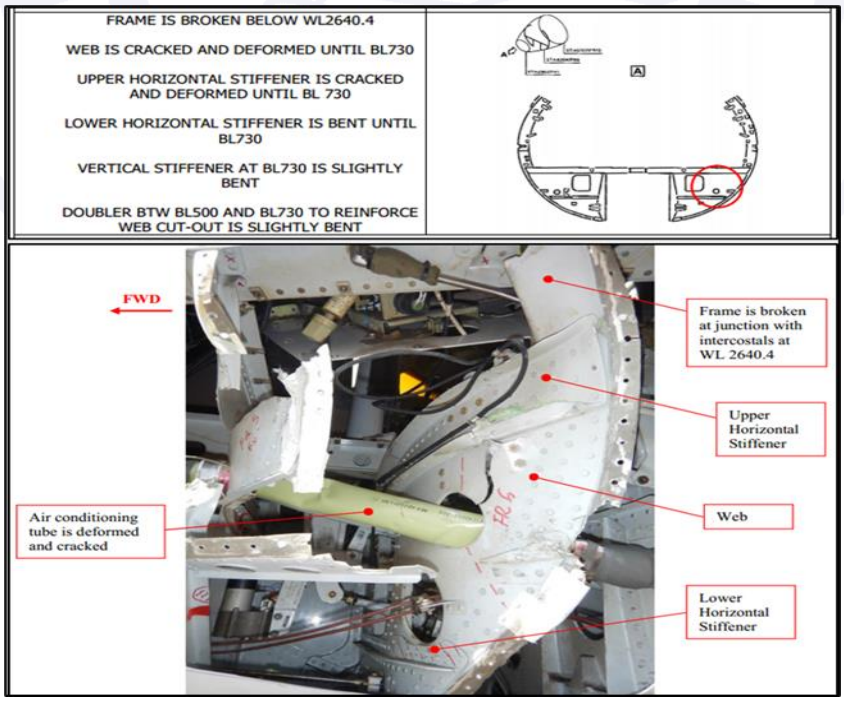


Figure 6 - Damage to frame 5 (Source: ATR).

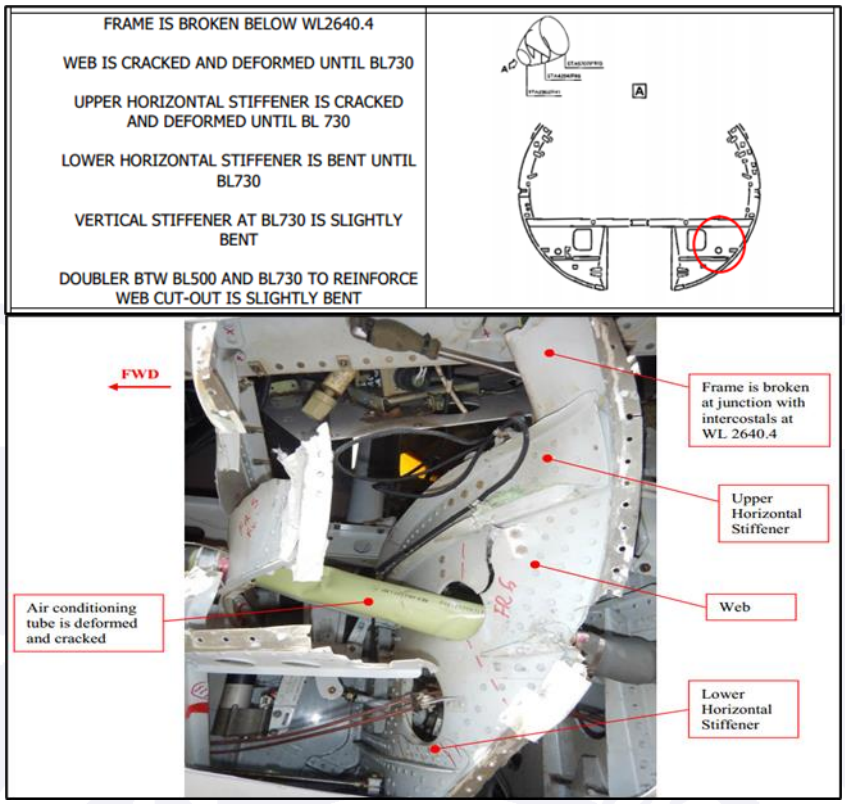


Figure 7 - Damage to frame 6 (Source: ATR).

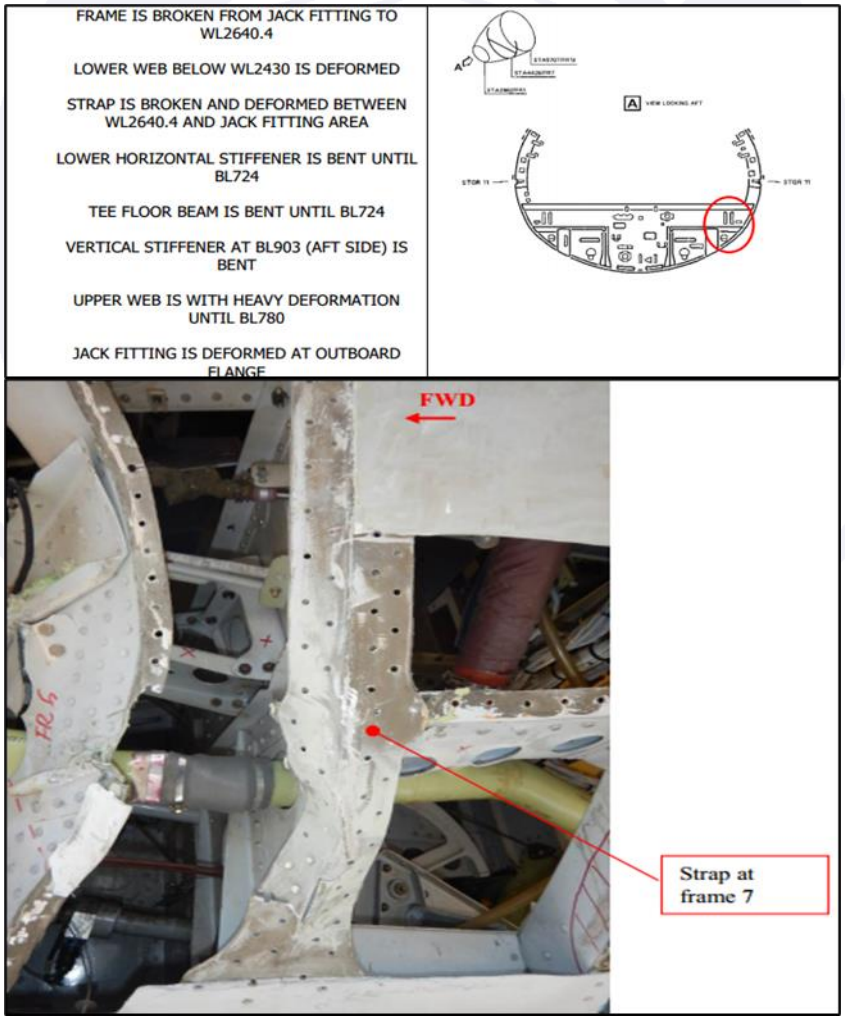


Figure 8 - Damage to frame 7 (Source: ATR).

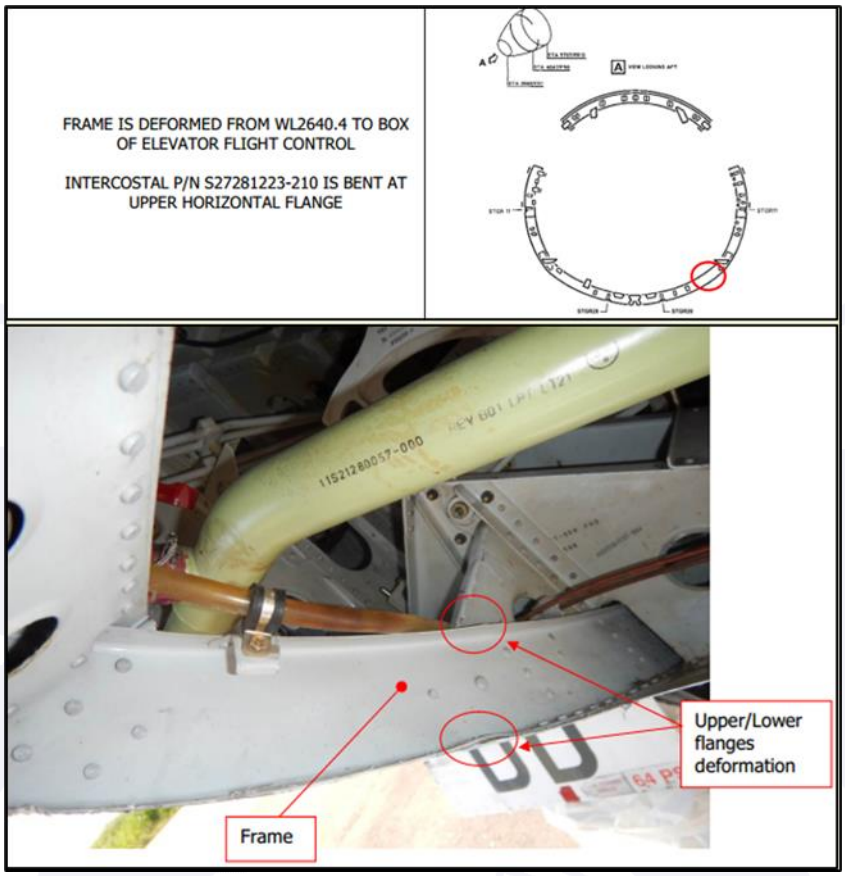


Figure 9 - Damage to frame 8 (Source: ATR).

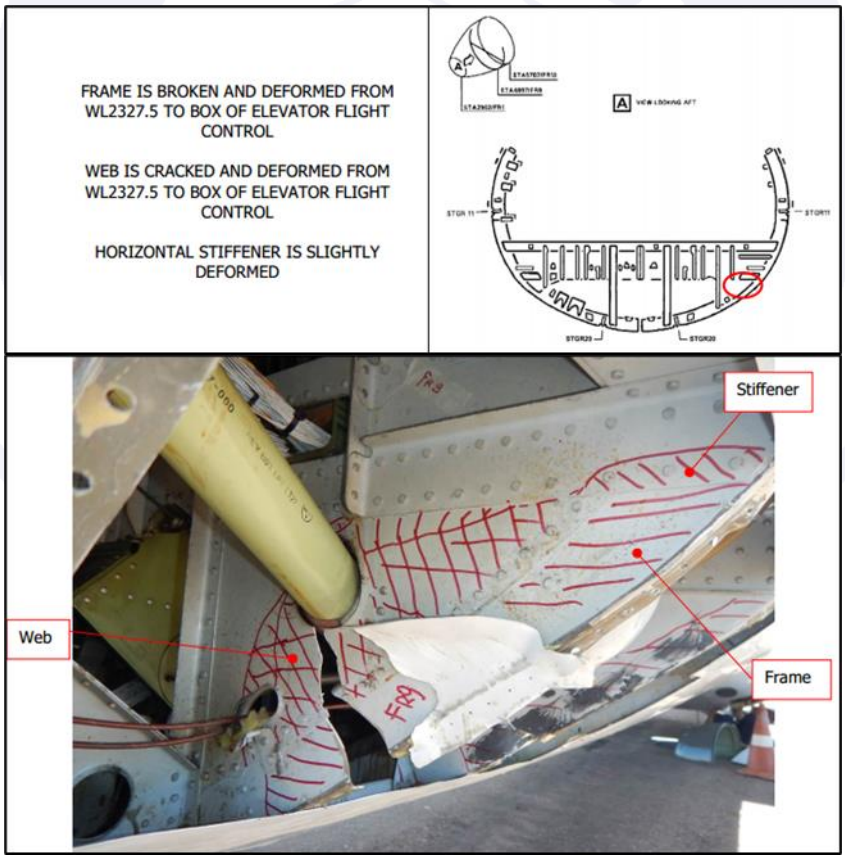


Figure 10 - Damage to frame 9 (Source: ATR).

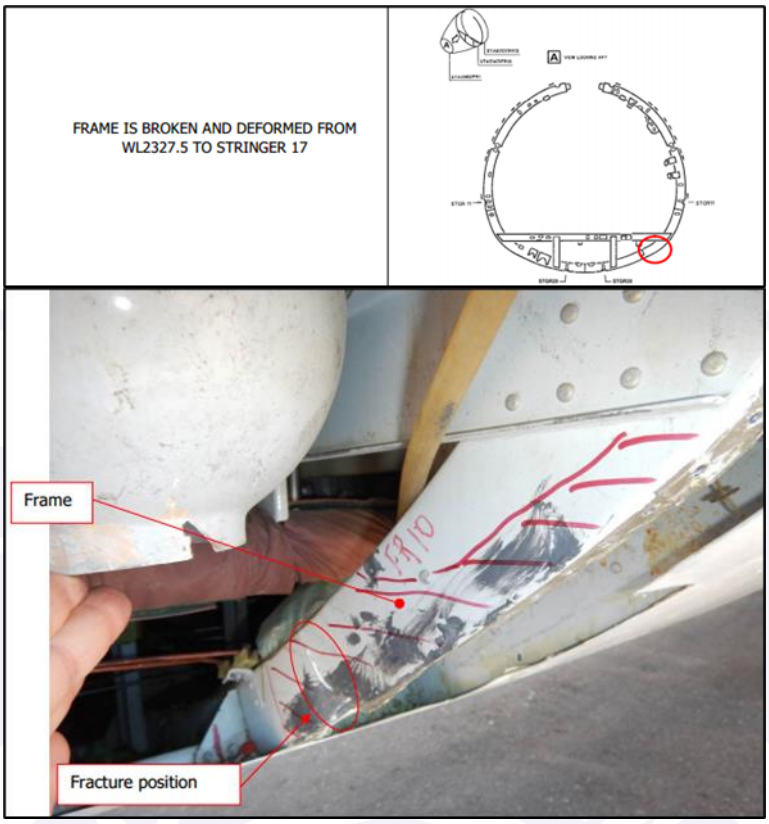


Figure 11 - Damage to frame 10 (Source: ATR).

The aircraft had damage in frames 25 and 27 (Figures 12 and 13).

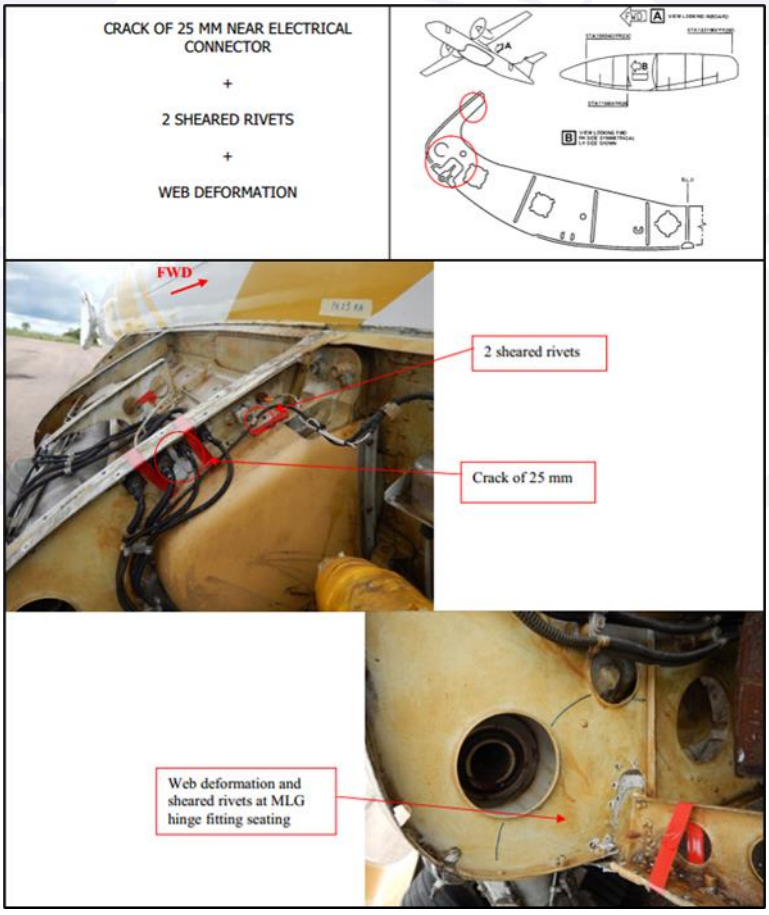


Figure 12 - Damage to frame 25 (Source: ATR).

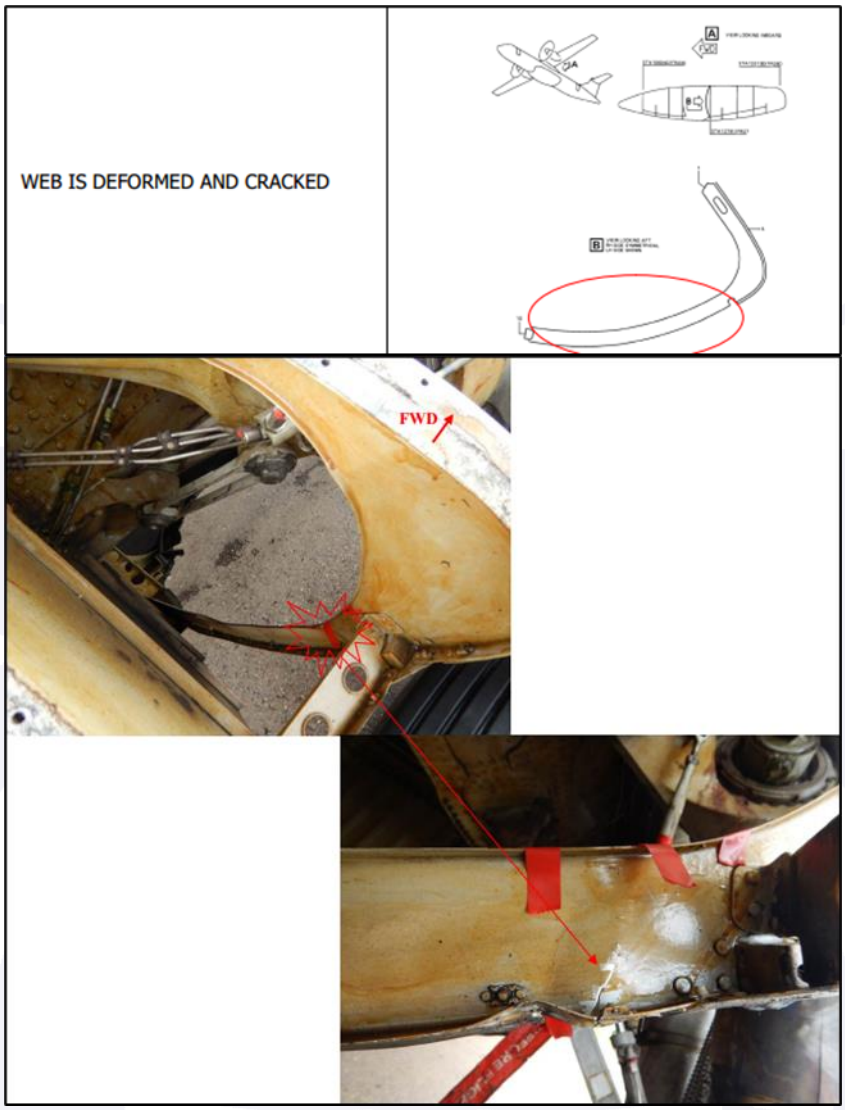


Figure 13 - Damage to frame 27 (Source: ATR).

1.4 Other damage.

Two concrete posts and approximately 72m of soybean plantation were damaged during the aircraft's run on the ground.

1.5 Personnel information.

1.5.1 Crew's flight experience.

Flight Hours		
	Pilot	Copilot
Total	5.018:00	5.567:00
Total in the last 30 days	55:26	57:50
Total in the last 24 hours	05:31	05:31
In this type of aircraft	2.218:00	3.940:00
In this type in the last 30 days	55:26	57:50
In this type in the last 24 hours	05:31	05:31

N.B.: The data related to the flown hours were obtained through the operator. The total flight hours data were provided by the pilots themselves and have approximate values.

1.5.2 Personnel training.

The pilot took the PPR course at the Biritiba Mirim Aeroclub - SP, in 2003.

The copilot took the PPR course at the São Paulo Aeroclub - SP, in 2000.

1.5.3 Category of licenses and validity of certificates.

The pilots had the PLA License and had valid AT47 aircraft type Rating (which included the ATR-72-212A model) and IFRA Rating.

1.5.4 Qualification and flight experience.

The pilots were qualified for the kind of flight.

However, it would be the first time that the commander would land on SBRD since he was hired by the operator.

The copilot, in turn, had landed in SBRD seven times before the accident's flight, six times operating an E145 jet, during 2012, and once operating the ATR-72 aircraft (same model of the accident), in 23DEC2015. Whenever he landed in the locality, he was not in control of the aircraft, since the operation at that Aerodrome was restricted to the commander.

1.5.5 Validity of medical certificate.

The pilots had valid CMAs.

1.6 Aircraft information.

The aircraft, serial number 562, was manufactured by ATR - GIE *Avions de Transport Régional*, in 1998, and it was registered in the TPR category. It had flown a total of 36,094 hours and 30 minutes since its manufacture.

The aircraft had valid Airworthiness Certificate (CA).

The technical maintenance records were considered updated.

The last inspection of the aircraft, the “Check A” type was carried out on 06JAN2016 by the maintenance organization *Passaredo Transportes Aéreos* S.A, in Ribeirão Preto - SP, with the aircraft having flown 41 hours and 6 min after the inspection.

According to the FCOM, Part 1, Chapter 16, Section 40, Page 4, Revision APR 2008, the engine throttle pedestal had certain TLA values for positions corresponding to the power lever. Among these values, we highlight the value of 37º for the Flight Idle (FI) position, minimum power allowed in flight (Figure 14).

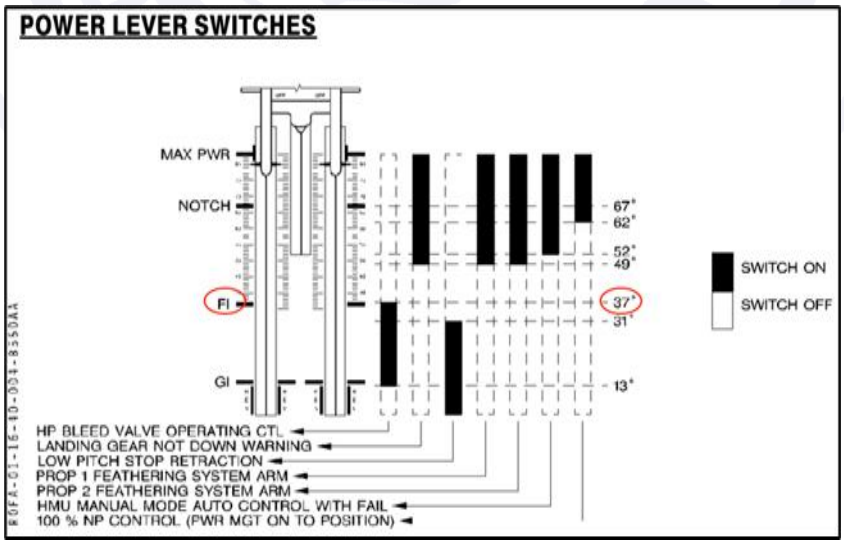


Figure 14 - Engine power levers with TLA angles. (Source: FCOM).

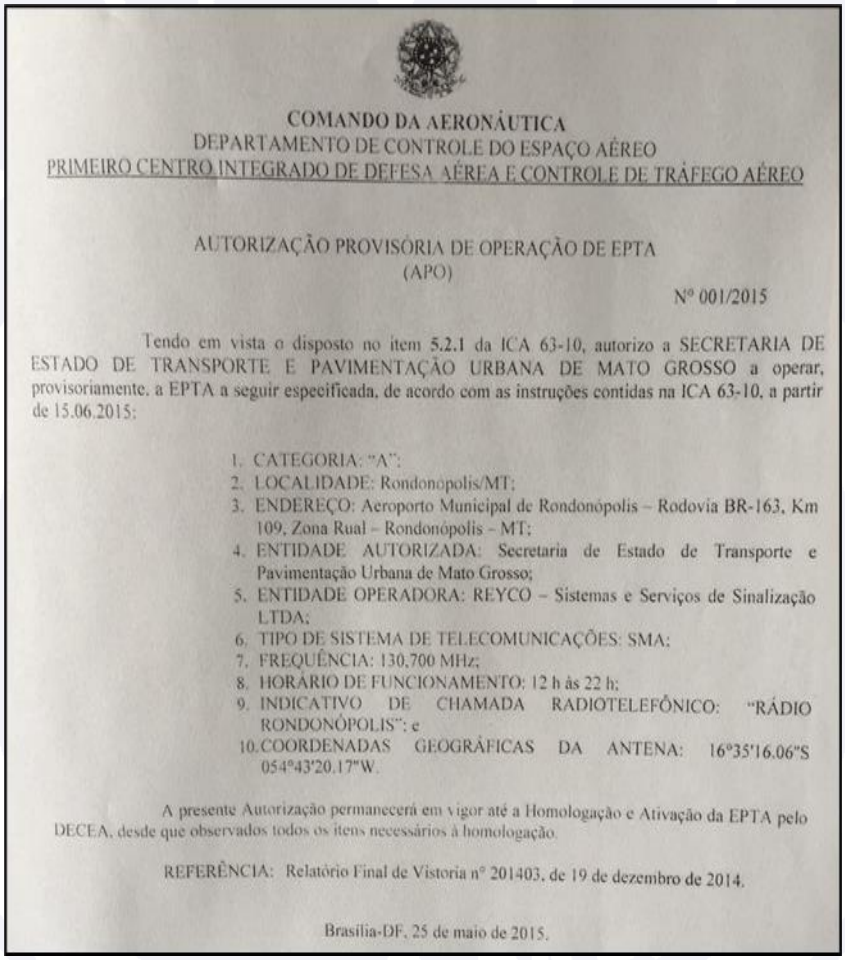
1.7 Meteorological information.

The EPTA provided AFIS and Meteorological Information in SBRD.

Regarding meteorological information, this was provided through the issuance of METARs and SPECIs.

The EPTA - Rondonópolis was under the responsibility of the Mato Grosso State Secretary of Transportation and Urban Paving, which hired the company REYCO *Sistemas e Serviços de Sinalização* Ltd. as Operating Entity, as specified in the APO of EPTA n° 001/2015, issued by the CINDACTA-1, on 25MAY2015 (Figure 15).

REYCO was approved by the DECEA to develop the EPTA Category "A" Operation activities, as demonstrated by the CET n° 1/2013, of 08FEB2013 (Figure 16).



COMANDO DA AERONÁUTICA
DEPARTAMENTO DE CONTROLE DO ESPAÇO AÉREO
PRIMEIRO CENTRO INTEGRADO DE DEFESA AÉREA E CONTROLE DE TRÁFEGO AÉREO

AUTORIZAÇÃO PROVISÓRIA DE OPERAÇÃO DE EPTA
(APO)

Nº 001/2015

Tendo em vista o disposto no item 5.2.1 da ICA 63-10, autorizo a SECRETARIA DE ESTADO DE TRANSPORTE E PAVIMENTAÇÃO URBANA DE MATO GROSSO a operar, provisoriamente, a EPTA a seguir especificada, de acordo com as instruções contidas na ICA 63-10, a partir de 15.06.2015:

1. CATEGORIA: "A";
2. LOCALIDADE: Rondonópolis/MT;
3. ENDEREÇO: Aeroporto Municipal de Rondonópolis – Rodovia BR-163, Km 109, Zona Rual – Rondonópolis – MT;
4. ENTIDADE AUTORIZADA: Secretaria de Estado de Transporte e Pavimentação Urbana de Mato Grosso;
5. ENTIDADE OPERADORA: REYCO – Sistemas e Serviços de Sinalização LTDA;
6. TIPO DE SISTEMA DE TELECOMUNICAÇÕES: SMA;
7. FREQUÊNCIA: 130,700 MHz;
8. HORÁRIO DE FUNCIONAMENTO: 12 h às 22 h;
9. INDICATIVO DE CHAMADA RADIOTELEFÔNICO: "RÁDIO RONDONÓPOLIS"; e
10. COORDENADAS GEOGRÁFICAS DA ANTENA: 16°35'16.06"S 054°43'20.17"W.

A presente Autorização permanecerá em vigor até a Homologação e Ativação da EPTA pelo DECEA, desde que observados todos os itens necessários à homologação.

REFERÊNCIA: Relatório Final de Vistoria nº 201403, de 19 de dezembro de 2014.

Brasília-DF, 25 de maio de 2015.

Figure 15 - APO n° 001/2015.

DECEA

DEPARTAMENTO DE CONTROLE DO ESPAÇO AÉREO

Certificado de Especialização Técnico-Operacional (CET)

Nº 1/2013

REYCO - SISTEMAS E SERVIÇOS DE SINALIZAÇÃO LTDA.

*De acordo com o disposto no item **2.3.4** da ICA 63-10 (ESTAÇÕES PRESTADORAS DE SERVIÇOS DE TELECOMUNICAÇÕES E DE TRÁFEGO AÉREO - EPTA), homologo a Prestadora de Serviços Especializados, acima indicada, para desenvolver as atividades relacionadas ao Sistema de Controle do Espaço Aéreo a seguir discriminadas:*

- *Operação de EPTA Categorias "A" e "C";*
- *Implantação de EPTA Categorias "A", "B" e "C";*
- *Gerenciamento de EPTA Categorias "A", "B" e "C"; e*
- *Manutenção de EPTA Categorias "A", "B" e "C".*

Rio de Janeiro, 8 de fevereiro de 2013.

Tenente-Brigadeiro do Ar Marco Aurélio Gonçalves Mendes
Diretor-Geral do DECEA

Figure 16 - CET n° 1/2013.

According to the APO 001/2015, the EPTA of Rondonópolis, also known as Rondonópolis Radio, had working period from 12:00 to 22:00. However, during the interviews, it was found that EPTA's working period was conditioned to the movement of regular transport aviation at the Aerodrome.

Whenever the EPTA opened or closed, a SPECI message was published, with the weather conditions recorded at the time.

During the period it was in operation, the EPTA issued a METAR every full hour.

The Rondonópolis Radio OAS was responsible for performing visual observation of the weather conditions and making the SPECI and METAR messages.

To determine horizontal visibility values, the OAS used two charts of reference points, as shown in Figures 17 and 18.

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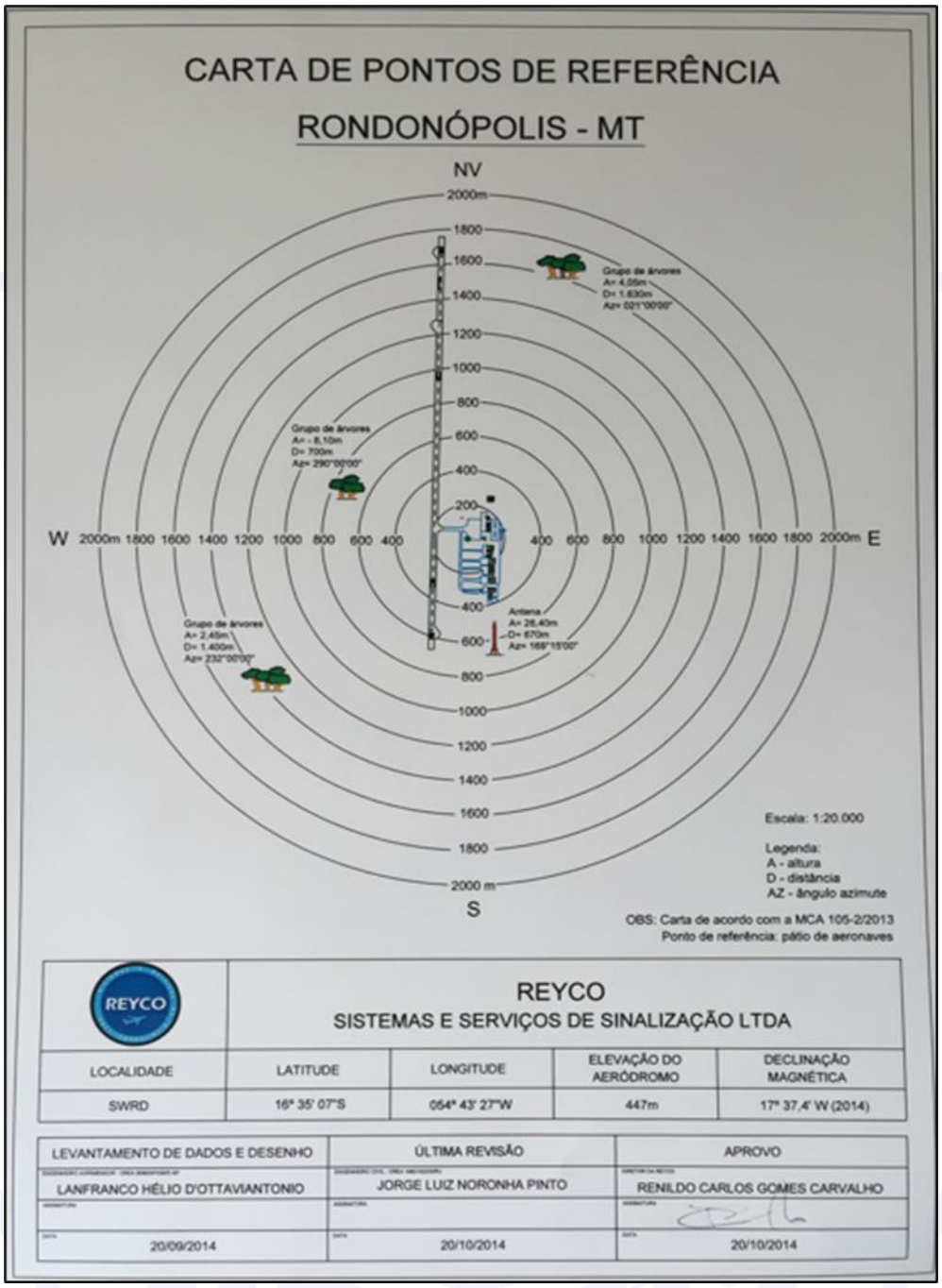

Figure 18 – Chart of Reference points up to 20km.

The publication that dealt with the rules for sending METAR messages was the ICA n° 105-1, of 23DEC2013. In accordance with the ICA items 3.6.3 and 3.6.4, the OAS should send the METAR within five minutes after the full hour to which the information referred. If the information were sent after this period, the message would be considered delayed.

When a METAR message was sent after five minutes beyond the full hour, the DECEA database recorded the moment when the message was transmitted, for the purpose of punctuality statistics. Only the times of messages considered late were recorded in the system. The data relating to messages received within the deadline established by the ICA 105-1 was not stored.

There was no record of delay in the DECEA database for the METAR and SPECI messages issued by the EPBR of SBRD on 08JAN2016 and 09JAN2016.

At 2000 (UTC) on 08JAN2016, the EPTA issued the METAR with the following information:

METAR SBRD 082000Z 04004KT 9999 FEW020 SCT100 25/23 Q1007=

On the same day, at 2030 (UTC), when it was closing, the EPTA issued a SPECI with the following information:

SPECI SBRD 082030Z 00000KT 9999 FEW020 BKN100 25/23 Q1007=

The METAR messages from 2100 (UTC), 2200 (UTC), and 2300 (UTC) on 08JAN2016, as well as from 0000 (UTC) and 0100 (UTC) on 9JAN2016 were not made, due to the EPTA being closed in that period.

At 0033 (UTC) on 09JAN2016, the PR-PDD took off from SBBR to SBRD, having the last available meteorological information the METAR of 2000 (UTC) and the SPECI of 2030 (UTC), both messages from 08JAN2016.

At 0130 (UTC) on 09JAN2016, when it was reactivating its operation, the EPTA issued a SPECI with the following information:

SPECI SBRD 090130Z /////KT 1000 FG VV010 ///// Q1010=

When the SPECI was issued at 0130 (UTC), the PR-PDD aircraft was already in flight from SBBR to SBRD.

At 0200 (UTC) on 09JAN2016, the EPTA issued a METAR with the following information:

METAR SBRD 090200Z 10007KT 4000 BR SCT007 SCT100 23/23 Q1011=

The EPTA issued a SPECI with the time of 0220 (UTC), with the following information:

SPECI SBRD 090220Z 10005KT 1000 BCFG NSC 22/22 Q1011=

At 0226 (UTC), the aircraft touched the SBRD runway in final landing.

On the night of 08JAN2016 to 9JAN2016, the moon was at the end of its last quarter phase.

On 08JAN2016, the moonrise occurred at 0524 (UTC-2), and the moonset occurred at 1833 (UTC-2).

The moonrise on 09JAN2016 took place only at 0617 (UTC-2).

In the interval between 1833 (UTC-2) on 08JAN2016 and 0617 (UTC-2) on 09JAN2016 it is possible to state that the night had no moon.

1.8 Aids to navigation.

The Maestro Marinho Franco Aerodrome (SBRD), Rondonópolis - MT, had night marking lights. However, it did not have luminous visual aids for approaches, such as: ALS, VASIS or PAPI.

The RBAC n° 154, Amendment 01, dated 12JUN2012, paragraph 154.305, (j) (1) (i) (B), items (1) and (2) stated that:

> 154,305 - Lights
>
> (j) Approach ramp visual systems
>
> (1) Application
>
> (i) A visual approaching ramp indicator system should be designed to assist in approaching a landing and takeoff runway, whether or not the runway has other visual aids or instruments, when one or more of the following conditions are present:
>
> (A) the runway is used by turbo-jets or other aircraft with similar approach guidance requirements;
>
> (B) the pilot of any type of aircraft may have difficulties in judging the approach due to:

> (1) inadequate visual orientation, such as when approaching an aquatic or terrain surface without visual references during the day, or in the absence of sufficient external lights in the approach area at night; or
>
> (2) mistaken information, such as that produced by neighboring lands with illusory characteristics or slopes in the runway;
>
> [...]

Paragraph 154.5, letter (d) of the same Regulation provided that:

> 154.5 - Standards
>
> (d) The standards defined in this regulation are subject to periodic reviews. In general, unless the ANAC deems it necessary and sets a specific deadline, the existing airport facilities do not need to be immediately modified in accordance with the new requirements, until the installation is replaced or improved to accommodate aircraft that have higher requirements.

Due to the different possibilities of interpretation of item 154.5 (d), the ANAC issued Decision n° 134, in 17SEPT2014, establishing the interpretation regarding the applicability of the RBAC devices n° 154.

> Art. 1st Fix the interpretation of paragraph 154.5 (d) of the RBAC nº 154, to clarify that the requirements foreseen in the regulation apply to the following cases:
>
> I - airport facilities that did not exist on 12MAY2009; and
>
> II - airport facilities existing on 12MAY2009:
>
> a) prevised in paragraphs 154,209 (a), 154,305 (f), 154,501 (a) (5) and D.13 (d) of RBAC n° 154, in accordance with specific requirements and deadlines;
>
> b) that are replaced or improved after this date to accommodate aircraft that have higher requirements;
>
> c) when determined by the ANAC in airport operational certification processes or in specific programs to adapt infrastructures to the rules of the RBAC n° 154; or
>
> d) in proven exceptional cases, when the ANAC, in view of the high operational risk identified, deems it necessary and sets a specific deadline.
>
> [...]

The Rondonópolis Aerodrome had an opening date prior to 12MAY2009.

1.9 Communications.

In ICA 105-1 METEOROLOGICAL INFORMATION DISSEMINATION, there was no guidance on the phraseology to be used by the OAS when passing on meteorological information to aircraft. The publication dealing with the topic of Air Traffic Phraseology, in force at the time of the occurrence was the MCA n° 100-16 AIR TRAFFIC PHRASEOLOGY, from 18NOV2013.

The MCA 100-16 did not provide detailed information regarding the obligation for the OAS to pass on the information contained in the METAR to an aircraft that requested meteorological conditions at the Aerodrome. However, it provided examples of communications between Radio and aircraft in its chapter 3, item 3.6, subitem 3.6.1.

Example of an Aerodrome operating under visual conditions:

> PT KST, Altamira Radio roger, calm wind, altimeter adjustment or QNH one zero one two, temperature 22°, Aerodrome operates visual, estimated ceiling one five zero zero feet, visibility 5,000 meters due to smoke, NDB Altamira is down, there is no known traffic. Inform wind leg.

Example of an aerodrome operating under IFR conditions:

> ONE 6344, Radio Altamira roger, wind zero eight zero degrees, two knots, altimeter setting one zero zero nine, Aerodrome under IFR conditions, visibility three thousand

meters, light rain, ceiling estimated eight zero zero feet. There is no known traffic. Temperature two three.

The MCA 100-16, which entered into force on 04JAN2021, also did not contain detailed guidance on the obligation for the OAS to pass on the information contained in the METAR to an aircraft requesting meteorological conditions at the Aerodrome.

Item 8.5.7 BASIC INFORMATION ELEMENTS FOR AIRCRAFT, from the ICA 100-37 AIR TRAFFIC SERVICES, detailed the information to be passed by the AFIS agency to aircraft in flight. However, it did not make clear what the source of this information would be, nor did it state that the OAS should read the METAR in effect for the aircraft. The update of the ICA 100-37, in force since 01DEC2020, also did not provide this guidance.

The Rondonópolis Radio' OAS communicated informally with the crew by passing on information on weather conditions recorded in SBRD.

As it had a direct influence on the operational decisions of the crew, the informality of communications between the OAS and the aircraft is described in item 1.18 Operational Information of this report.

1.10 Aerodrome information.

The Maestro Marinho Franco Aerodrome was public, managed by the Rondonópolis City Hall – MT.

The runway was made of asphalt, with thresholds 02/20, dimensions of 1.850m x 30m, with elevation of 1.467 feet.

The Aerodrome was certified to VFR visual operations during the day and night.

The meteorological minimums, established in the ICA 100-12 AIR RULES for this type of operation, were 5,000m of horizontal visibility and a ceiling of 1,500ft (approximately 450m).

As previously explained, the Aerodrome did not have an air traffic control service, but there was an EPTA that provided AFIS services, in addition to meteorological information services. Regarding the AFIS service, flight information was provided via radio. This station was operated by a private entity, certified by the DECEA.

The runway was surrounded by soybean plantations and local vegetation.

The Aerodrome was located about 20 km from the city center of Rondonópolis and there were no buildings or sources of artificial lighting in the neighborhood.

1.11 Flight recorders.

The aircraft was equipped with an FDR L-3, model FA2100 FDR (solid state memory), PN 2100-4043-00 and SN 468245, with a recording capacity of 128 wps (words per second).

It also had an L-3 CVR, model FA2100 CVR (solid state memory), PN 2100-1020-02 and SN 874041, equipped with 4 channels with recording capacity of two hours.

The CVR recording channels were distributed as follows: a channel in the audio box of the commander's flight seat, a channel in the audio box of the copilot's flight seat, a channel in the audio box of the jump seat, and a channel with an open microphone to record the cabin's ambient sound.

The data of both recorders were preserved and the content was downloaded at the CENIPA's LABDATA.

The recording of the channel with an open microphone to record the ambient sound of the cabin had a high noise level, a fact that prevented the comprehension of most of the

audios captured by this channel. In this way, only a few excerpts of conversations between the pilots inside the cabin were understandable.

The recordings of the dialogues captured by the other channels had good quality.

1.12 Wreckage and impact information.

The aircraft touched the ground about 400m before the threshold 02 of the SBRD runway, outside the patrimony area of the Aerodrome.

The contact with the terrain took place in one of the soybean plantations that surrounded the Aerodrome. The plane traveled 42m in contact with the ground, until it collided with two concrete posts of the patrimony fence. After the collision, it covered another 30m over the vegetation, within the patrimony area of the Aerodrome, until it took off again.

The marks left on the ground had a displacement course approximately equal to 022° in relation to the magnetic North (N), 73m away from the axis of the SBRD runway 02 (Figure 19).

Figure 19 - Sketch of the aircraft's displacement on the ground.
Source: Adapted from Google Earth.

1.13 Medical and pathological information.

1.13.1 Medical aspects.

No evidence was found that problems of physiological nature could have affected the flight crew performance.

1.13.2 Ergonomic information.

Nil.

1.13.3 Psychological aspects.

Nil.

1.14 Fire.

There was no fire.

1.15 Survival aspects.

Nil.

1.16 Tests and research.

Nil.

1.17 Organizational and management information.

The operator provided the crew with an Airport Briefing for the location (Figures 20 and 21). This documentation was intended to provide general information about the Aerodrome, in addition to defining recommendations and operational restrictions.

The Airport Briefing of SBRD, issued by the operator on 10SEPT2015, prohibited the operation with contaminated runway or under heavy rain, as well as determined the operation of the aircraft to the commander in that location.

In addition to the restrictions already mentioned, the document warned that the Aerodrome was subject to black hole at both ends.

PASSAREDO

AIRPORT BRIEFING
OPL - APB 024-15

REVISÃO: 03
VERSÃO: 00
DATA: 10/09/2015

RONDONÓPOLIS – MT (SBRD)

INFORMAÇÕES DA PASSAREDO

FREQUÊNCIA DO DESPACHO E CCO: 132.000 MHz

RESTRIÇÕES OPERACIONAIS

- **É PROIBIDA A OPERAÇÃO EM PISTA CONTAMINADA.**
- NÃO POUSAR SOB CHUVA FORTE.
- OPERAÇÃO EXCLUSIVA DO COMANDANTE NO POUSO, OU QUANDO APLICÁVEL, DO COMANDANTE EM INSTRUÇÃO.

RECOMENDAÇÕES OPERACIONAIS

- FAÇA O TOQUE NA MARCA DE 1000 FT, MANTENDO A VAPP.
- ATENTAR PARA AOS TRÁFEGOS LOCAIS.
- RISCO DE *RUNWAY EXCURSION*.
- AERÓDROMO SUJEITO A *BLACK HOLE* EM AMBAS AS CABECEIRAS.
- ATENÇÃO PARA A ENTRADA E MANOBRAS NO PÁTIO.

CONDIÇÕES LIMITANTES DE VENTO:

	TRAVÉS MAXIMO*	CAUDA MÁXIMO*
PISTA SECA	25 KT	10KT
PISTA MOLHADA	15 KT	PROIBIDO

*COMPONENTE DE VENTO

INFORMAÇÕES DO AERÓDROMO

- **ELEVAÇÃO: 1467 FT** UTC -4 RFFS CAT-5
- **PISTA 02 / 20 (1850 X 30M ASPH)**
- OPERA VFR DIURNO E NOTURNO
- VASIS OU PAPI NÃO DISPONÍVEL
- RODODIF JUVENTUDE ZYI-401 FREQ. 660 / CLUBE ZYI-423 FREQ. 930
- **AFIS FREQ. 130.70 MHz (HR SER MON TIL FRI 03:30–06:30 12:00–16:00 18:00–22:00 / SAT 03:00–06:30 / SUN 17:30–23:30).**
- CONSULTE NOTAM EM VIGOR

IMAGEM DISPONÍVEL NO VERSO

Elaborado por:
Cmte. Clayton Takesako
Chefe Flight Standards

Aprovado:
Cmte. Rui Beja
Gerente de Operações

Figure 20 - Airport Briefing to SBRD (Front)

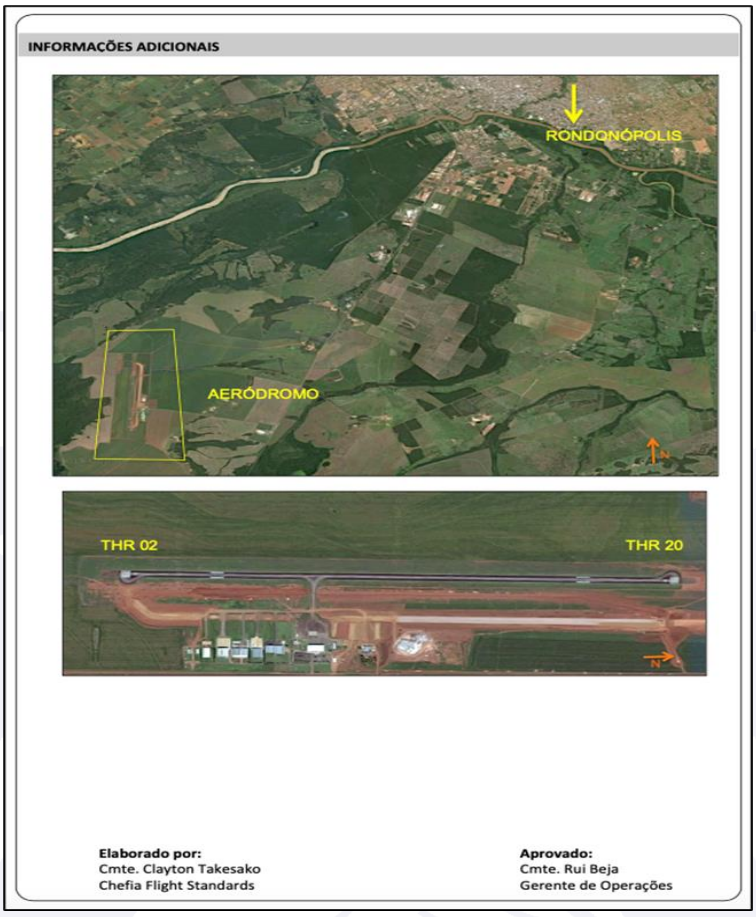

Figure 21 - Airport Briefing to SBRD (Back)

Although the Airport Briefing mentions the term black hole, there was no explanation of the phenomenon in the document, the MGO and the SOP, nor the risks involved when it occurs during approaches.

1.18 Operational information.

The aircraft was within the weight and balance limits specified by the manufacturer.

The commander performed the last simulator training on 04MAR2015. The training section lasted four hours and took place at the Governador André Franco Montoro Aerodrome (SBGR), São Paulo - SP. Visual traffic exercises, go-around procedure - the missed approach type, go-around procedure - the reject approach type, and three complete landings were carried out, among others. In all of these exercises, the learner received a satisfactory grade (SA) from the instructor.

In the area “I - GENERIC AND NON-TECHNICAL” of the FAP, the instructor evaluated the following items as SA: Assistance (Pilot monitoring), Call-Out, CRM (Cooperation), CRM (Leadership), CRM (Situational Awareness) and CRM (Decision Making). The crewmember was considered approved by the examiner. The flight-related FAP contained positive comments on the performance of the crew, noting that they conducted the flight in accordance with the airline's SOP and MGO.

The copilot performed the last simulator training on 18MAR2015. The training section lasted four hours and had SBGR as its setting. Visual traffic exercises, go-around procedure - the missed approach type, go-around procedure - the reject approach type, and four complete landings were carried out, among others. In all of these exercises the learner received an SA grade from the instructor. In the area “I - GENERIC AND NON-TECHNICAL” of FAP, the instructor evaluated the following items as SA: Assistance (Pilot monitoring), Call-Out, CRM (Cooperation), CRM (Leadership), CRM (Situational Awareness), CRM

(Decision Making). The crewmember was considered approved by the examiner. The flight-related FAP contained positive comments about the pilot's performance, noting that the examiner considered the crewmember able for the role in the airline.

On the date of the accident, the aircraft took off from SBBR to SBRD, in order to carry out a regular passenger transport flight.

It was the third leg of the day for that crew, with takeoff and landing scheduled for the night period.

It was the first time that the commander of the aircraft operated in SBRD and the eighth time that the copilot would land in that location.

The MGO, in its Section 3, Chapter 1 Flight Schedule, item 1.4 Crew Pairing, stated that:

> **1 Flight Schedule**
>
> **1.4 Crew Pairing 121.438 (B) FLT 3.3.2**
>
> It is the responsibility of the flight schedule to ensure that inexperienced crewmembers are not matched. The Flight Schedule must ensure that the pilot-in-command or second-in-command has at least 75 flight hours in operation en route as first or second in command.

In addition, item 2.11 Qualifications and Experience, Chapter 2, Section 3 of the MGO stated that:

> 2 Crewmembers
>
> 2.11 Qualifications and Experience 121,443 / 121,445
>
> The Operations Directory will ensure that Pilots have up-to-date knowledge and information regarding matters pertinent to the area of operations, each Aerodrome and each terminal area in which they will operate.
>
> [...]
>
> In the case of en route operations or Aerodromes classified as special, the following items will additionally be observed:
>
> • For operations on special Aerodromes, it is necessary that within the last 12 months, the Commander has made an approach to this Aerodrome (including landing and takeoff), or has qualified for the Aerodrome using an ANAC approved training device. FLT 2.4.1

The Rondonópolis Aerodrome was not considered special by the ANAC, nor by the operator. Therefore, there were no specific requirements for recent experience at the MGO to operate in the locality. However, SBRD had some peculiar characteristics:

- the Aerodrome runway was isolated and surrounded by soybean plantations;

- the closest source of significant artificial light was the city of Rondonópolis itself, about 20km away;

- there was no instrument approach chart or visual approach chart published for SBRD;

- the Aerodrome did not have lighting aid systems for visual approaches (ALS, PAPI, VASIS, etc.);

- there was no air traffic control agency in SBRD. The local EPTA provided AFIS service to the aircraft;

- in addition to providing AFIS service, EPTA also made METAR messages for the locality, including SPECI at the opening and closing times of the Station; and

- the landing and take-off operations in SBRD, during the day and night, were exclusively visual.

The meteorological minimums established in the ICA 100-12 AIR REGULATIONS, for visual operation, were 5,000m of horizontal visibility and a ceiling of 1,500ft.

At the time of the preparation for the flight leg between SBBR and SBRD, the last meteorological information from SBRD, which was available for consultation by the crew, was the EPEC closing SPECI, at 2030 (UTC) on 08JAN2016. In this SPECI, the horizontal visibility was above 10,000m and there were few clouds at 2,000ft in height, values above the minimum established for visual operation.

The aircraft took off from SBBR, at 0033 (UTC) on 09JAN2016, to SBRD. The gap between the time of the last available weather information and the time of departure was just over four hours.

At about 0156 (UTC), the crew made contact with the Rondonópolis Radio, in order to obtain information about the meteorological conditions at the Aerodrome. The dialogues related to this consultation were registered by the CVR:

> Radio communication between the PR-PDD aircraft and the EPTA Rondonópolis, starting at 0156 (UTC):
>
> **PR-PDD:** Rondonópolis Radio, good evening. Passaredo 2330.
>
> **EPTA:** Good evening Passaredo 2330, Rondonópolis. Proceed sir.
>
> **PR-PDD:** Positive. Level one eight zero. Sector Echo from Rondonópolis. Eighty-eight miles away. Estimating landing there zero two one nine, for the conditions.
>
> **EPTA:** Roger. At the moment the wind is one one zero degrees with five knots, altimeter is one zero one one, temperature two two degrees. I am providing the METAR of the hour, sir, the SPECI of one and ... one and thirty ... it was very foggy ...
>
> (the phone rings and the EPTA operator interrupts the transmission for a few seconds to answer the phone, then transmits again)
>
> ... very intense fog here in the South of the Aerodrome, but the horizontal visibility is already twenty km. The fog has already given a good spacing, but at the moment I still can't see the ... the sky is still obscured over the Aerodrome. The fog is already more ... more ... less dense, probably when you arrive it will be better. Horizontal visibility is already twenty km, but I still can't see the base of the clouds. And there is no traffic to report, sir. Report closer.
>
> **PR-PDD:** Positive. You will then report closer to 2330. Thanks for the information.
>
> **EPTA:** Okay.

In an interview, the OAS reported that, at the time of this communication with the aircraft, he was able to view the lights of the city of Rondonópolis. Knowing that the city was about 20 km from the Aerodrome, he passed on the horizontal visibility information equal to 20 km to the aircraft, even though the SPECI contained 1,000m.

At 0203 (UTC), the PR-PDD requested a descent from the ATS agency. The controller authorized the aircraft to descend to FL150, being the descent below that flight level at the commander's discretion. The controller also requested that the PR-PDD inform when in bilateral contact with the Rondonópolis Radio.

At 0208 (UTC), the PR-PDD informed the ATS agency that it was in bilateral contact with the Rondonópolis Radio. The ATS agency responded by reporting that the radar service was finished.

At 0210 (UTC), the PR-PDD made permanent contact with the EPTA (Rondonópolis Radio). The dialogues related to this communication were registered by the CVR:

> Radio communication between the PR-PDD aircraft and the EPTA Rondonópolis, starting at 0210 (UTC):
>
> **PR-PDD:** Rondonópolis Radio, Passaredo 2330 now definitely.

EPTA: Roger, Passaredo 2330.

PR-PDD: Positive. We are here now at twenty-five miles passing the one one zero to the traffic altitude.

EPTA: Aware, sir. At the moment, the Aerodrome with those old and friendly fog banks over the Aerodrome, but the wind has five knots, it is managing to dissipate, soon another one appears, then it dissipates, another one appears ... let's see how it will be.

PR-PDD: Ok then. I will inform you at the intersection, 2330.

EPTA: Roger, sir.

At 0213 (UTC), the PR-PDD makes another communication with the EPTA:

Radio communication between the PR-PDD aircraft and the EPTA Rondonópolis, starting at 0213 (UTC):

PR-PDD: The 2330 informs ... it's totally visual there with the Aerodrome. We are seeing a fog bank here, really, ah ... for the North sector of the city here, there is a really strong bank here ...

EPTA: Roger, here on the runway, apparently it has improved, it is less dense. I am noticing that the threshold two zero looks a little better but you can see better up there.

PR-PDD: Ah ... initially we are proceeding here to zero two, the 2330.

EPTA: Roger, sir. Wind one one zero degrees with five knots.

PR-PDD: Roger.

In any of the communications with the aircraft, the OAS performed the reading of the available METAR or SPECI messages. The radio operator was limited to providing informal descriptions of weather conditions, recorded at the time of the transmissions.

With the information received, the pilots decided to create a profile of visual approach for the threshold 02 of the SBRD runway.

The operator's SOP, Version 1, Revision 2, from 12AUG2015, established the operating parameters for approaches under visual flight rules (Visual Pattern). The document stated that a wind leg should be carried out at a height of 1,500ft, at least. At the end of the runway, the pilots should have an indicated speed of 170kt and lower the flaps to 15°. After the threshold abeam, the pilots should keep the straight for another 45 seconds. In this stretch of the wind leg, the pilots should start a descent up to 1,000ft in height, no less than that, at the beginning of the turn for the base leg. When starting the left turn, for the base leg, the landing gear should be lowered.

During the base leg, the pilots should lower the flaps to 30° and perform the “Before Landing Checklist”. In addition, they should continue on the descent until reaching 500ft in height, no less than that, at the end of the turn to fit the final approach axis.

Aligned with the runway axis, the pilots should decide to continue the approach for landing or to start a go-around procedure. If the decision was to proceed with the approach, the pilots should disconnect the autopilot when they were with the landing assured, and proceed to the landing. If they opted for a go-around procedure, they should follow the procedures contained in the SOP for this maneuver (Figure 22).

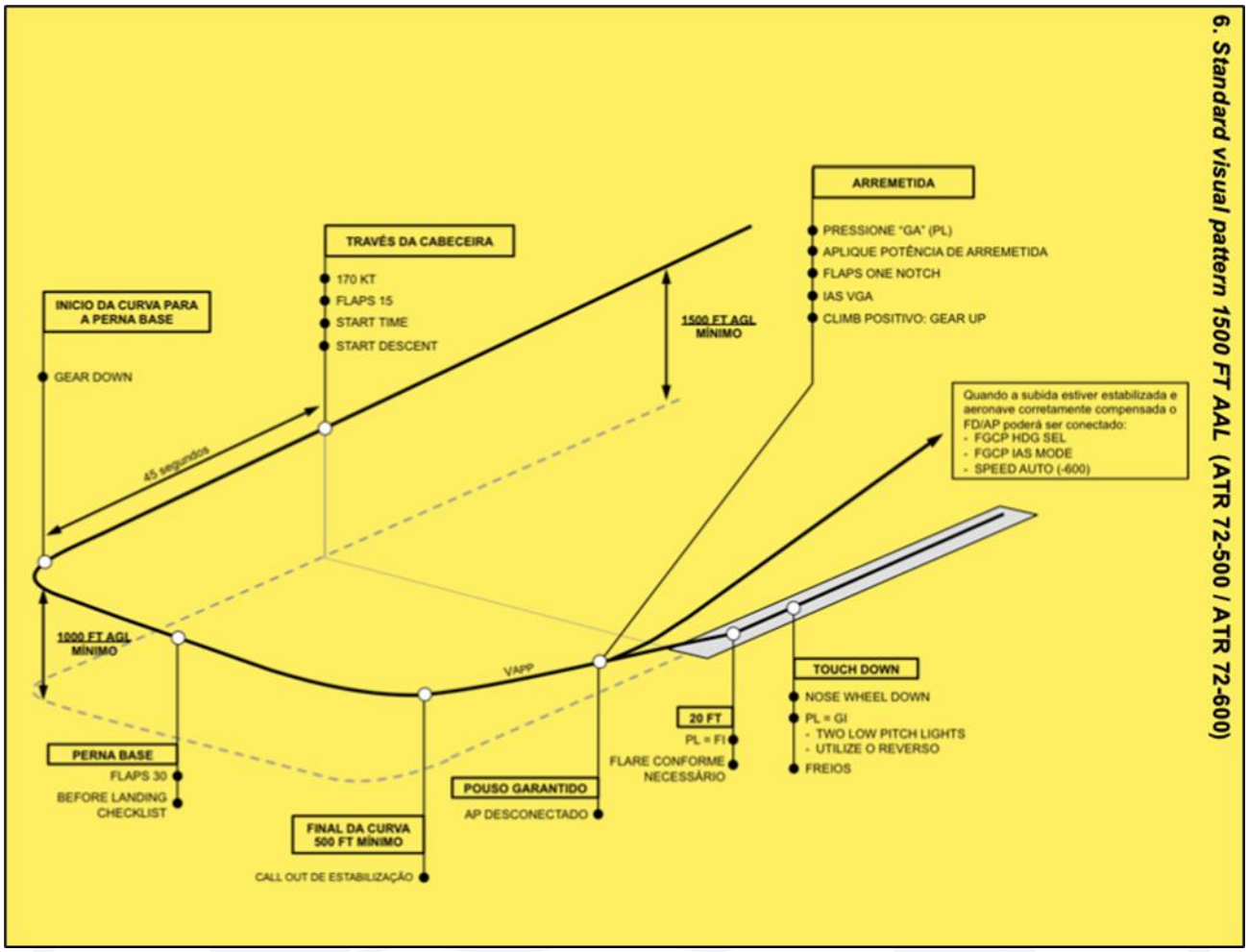

Figure 22 - Approach profile for constant visual landing of the operator's SOP.
Source: The Operator.

The SOP also defined the call-outs and procedures to be performed by the pilots during visual approaches. It is noteworthy that, when reaching 500ft of height, the pilots should check the flight parameters to define whether the aircraft was stabilized in the approach procedure, which is a defining criterion for continuing the approach or starting a go-around procedure (Figure 23).

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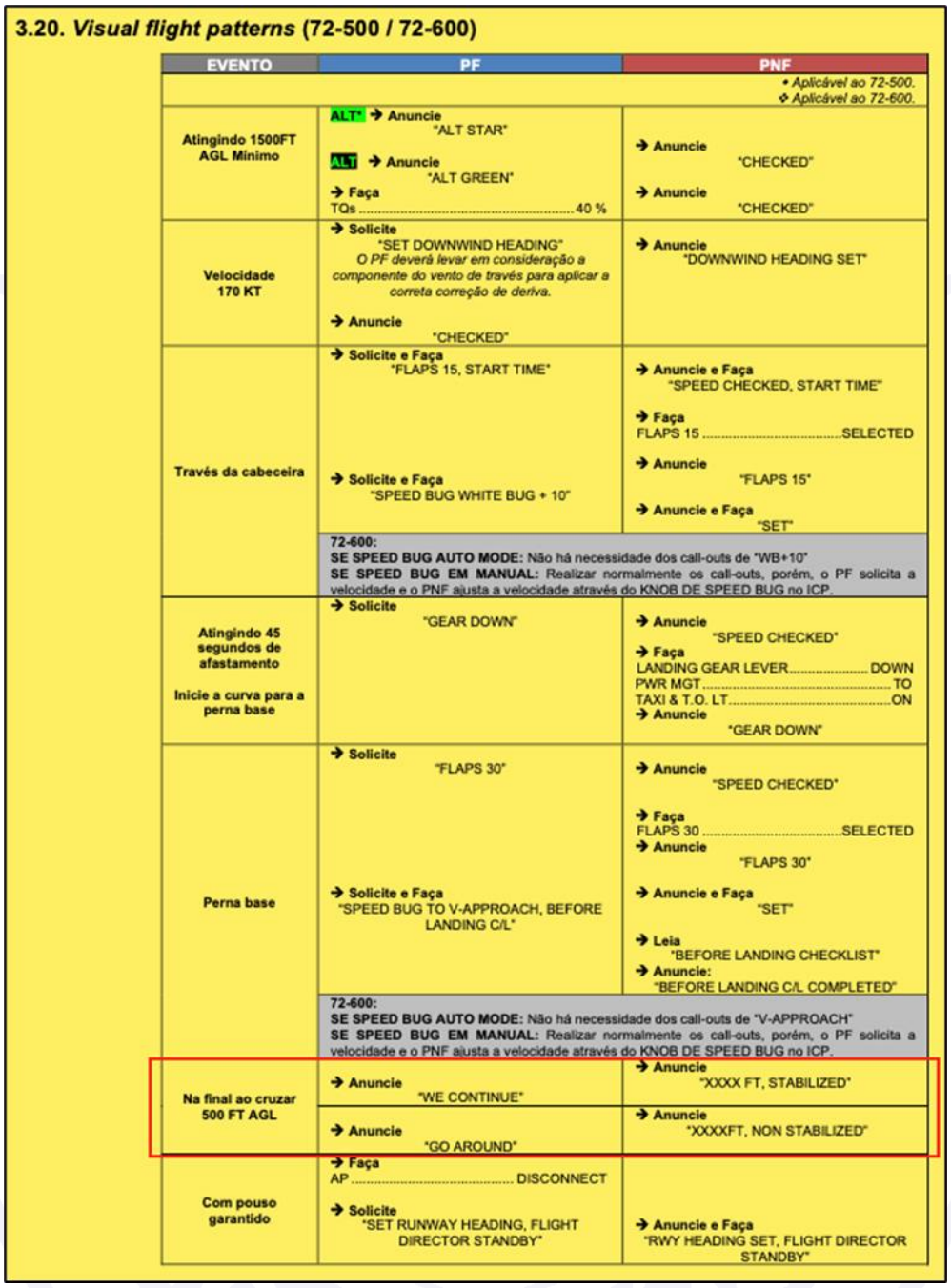

3.20. *Visual flight patterns* (72-500 / 72-600)

EVENTO	PF	PNF
		• *Aplicável ao 72-500.* ❖ *Aplicável ao 72-600.*
Atingindo 1500FT AGL Mínimo	**ALT*** → **Anuncie** "ALT STAR" **ALT** → **Anuncie** "ALT GREEN" → **Faça** TQs ..... 40 %	→ **Anuncie** "CHECKED" → **Anuncie** "CHECKED"
Velocidade 170 KT	→ **Solicite** "SET DOWNWIND HEADING" *O PF deverá levar em consideração a componente do vento de través para aplicar a correta correção de deriva.* → **Anuncie** "CHECKED"	→ **Anuncie** "DOWNWIND HEADING SET"
Través da cabeceira	→ **Solicite e Faça** "FLAPS 15, START TIME" → **Solicite e Faça** "SPEED BUG WHITE BUG + 10"	→ **Anuncie e Faça** "SPEED CHECKED, START TIME" → **Faça** FLAPS 15 ..... SELECTED → **Anuncie** "FLAPS 15" → **Anuncie e Faça** "SET"
	72-600: **SE SPEED BUG AUTO MODE:** Não há necessidade dos call-outs de "WB+10" **SE SPEED BUG EM MANUAL:** Realizar normalmente os call-outs, porém, o PF solicita a velocidade e o PNF ajusta a velocidade através do KNOB DE SPEED BUG no ICP.	
Atingindo 45 segundos de afastamento **Inicie a curva para a perna base**	→ **Solicite** "GEAR DOWN"	→ **Anuncie** "SPEED CHECKED" → **Faça** LANDING GEAR LEVER..... DOWN PWR MGT..... TO TAXI & T.O. LT..... ON → **Anuncie** "GEAR DOWN"
Perna base	→ **Solicite** "FLAPS 30" → **Solicite e Faça** "SPEED BUG TO V-APPROACH, BEFORE LANDING C/L"	→ **Anuncie** "SPEED CHECKED" → **Faça** FLAPS 30 ..... SELECTED → **Anuncie** "FLAPS 30" → **Anuncie e Faça** "SET" → **Leia** "BEFORE LANDING CHECKLIST" → **Anuncie:** "BEFORE LANDING C/L COMPLETED"
	72-600: **SE SPEED BUG AUTO MODE:** Não há necessidade dos call-outs de "V-APPROACH" **SE SPEED BUG EM MANUAL:** Realizar normalmente os call-outs, porém, o PF solicita a velocidade e o PNF ajusta a velocidade através do KNOB DE SPEED BUG no ICP.	
Na final ao cruzar 500 FT AGL	→ **Anuncie** "WE CONTINUE"	→ **Anuncie** "XXXX FT, STABILIZED"
	→ **Anuncie** "GO AROUND"	→ **Anuncie** "XXXXFT, NON STABILIZED"
Com pouso garantido	→ **Faça** AP ..... DISCONNECT → **Solicite** "SET RUNWAY HEADING, FLIGHT DIRECTOR STANDBY"	→ **Anuncie e Faça** "RWY HEADING SET, FLIGHT DIRECTOR STANDBY"

Figure 23 - Call-outs and procedures to be performed during a visual approach for landing. Highlight in red for the stabilization call-out to be carried out when it reaches 500ft in height.
Source: The Operator.

The MGO, in its Chapter 3, item 3.4 Stabilized Approach, stated that:

> **3.4 Stabilized approach** FLT 3.11.50; 3.11.59; 3.11.60; 3.11.66
>
> An approach should not be continued being compulsory to carry out the go-around procedure, if the aircraft is not in a stabilized approach below the following altitudes (safety window):
>
> I. VMC - 500 feet
>
> II. IMC - 1000 feet
>
> The conditions that define a stabilized approach are:
>
> III. The flight path must be correct;
>
> IV. Only small changes in the angle are necessary to maintain the flight path;

V. The speed of the aircraft is not greater than VRef + 20, and not less than VRef;

VI. The aircraft must be in the correct landing configuration;

VII. The rate of descent is not greater than 1,000 ft / min;

VIII. The power setting must be appropriate for the configuration of the aircraft;

IX. All briefings and checklists were carried out.

X. The descent profile on the final approach must maintain a constant path with a glide angle to the MDA. FLT_ 3.11.66

The high noise level in the CVR recordings made conversations between the pilots inside the cockpit unintelligible. Thus, it was not possible to verify the accomplishment of a descent and / or landing briefing, nor the enunciation of call-outs or compliance with checklist items during the traffic circuit. However, the FDR recorded the profile data developed by the aircraft.

The pilots crossed the Aerodrome, perpendicularly to the runway, at an altitude of approximately 3,900ft (2,433ft in height). Shortly after crossing the runway, the flaps were lowered to 15°, before starting the wind leg. Then, the aircraft turned to the left, starting a standard visual traffic circuit.

A wind leg was carried out parallel to the runway. At the beginning of it, the aircraft was approximately 3,700ft above sea level (2,233ft above the ground). During this segment, the landing gear was lowered and, fifteen seconds later, the flaps were lowered to 30°. At the end of the wind leg, the aircraft was configured for landing and was approximately 3,100ft high (1,633ft high), when the pilots started the left turn to enter the base leg.

Approximately in the middle of the base leg, the autopilot was disengaged (Autopilot OFF). During the base curve, the aircraft continued to lose altitude and, when entering the final approach, was at an altitude of approximately 2,100ft (633ft above the altitude of the Aerodrome). The time elapsed between the beginning of the base curve and the stabilization of the aircraft at the heading of the final approach was 1min30sec. The rate of descent during the base curve varied between 660ft/min and 1.380ft/min.

At the time of the beginning of the final approach for landing, the aircraft was at approximately 2,100ft of altitude (633ft in height), 1.9m far from the threshold 02, keeping an indicated speed 124kt, ground speed 118kt, with rate of descend 1,080ft/min, with landing gear down, and flaps at 30°. Theoritical Vref is 110kt. According to the wind information in their hands upon landing, theoretical Vapp should be 113kt.

Throughout the final approach, the maximum descent rate recorded by the FDR was 1,092ft/min and the minimum was 732ft/min (recorded two seconds before impact on the ground). The time elapsed between the moment the aircraft stabilized at the final approach heading and the impact against the ground was 45 seconds. Therefore, the average descent rate during the final approach was approximately 844ft/min.

When it reached 500ft above the Aerodrome altitude, the aircraft had a descent rate 960ft/min, speed 123kt, magnetic heading at 028°, configured for landing, TLA of the power lever of engine # 1 at 41.84º, torque of the engine # 1 in 14.5%, TLA of the power lever of engine # 2 in 41.14º and torque of engine # 2 in 9%.

Figure 24 illustrates the aircraft's path during the visual traffic landing procedure, as well as the path taken after touching the ground, go-around procedure and repositioned for final landing on the SBRD runway.

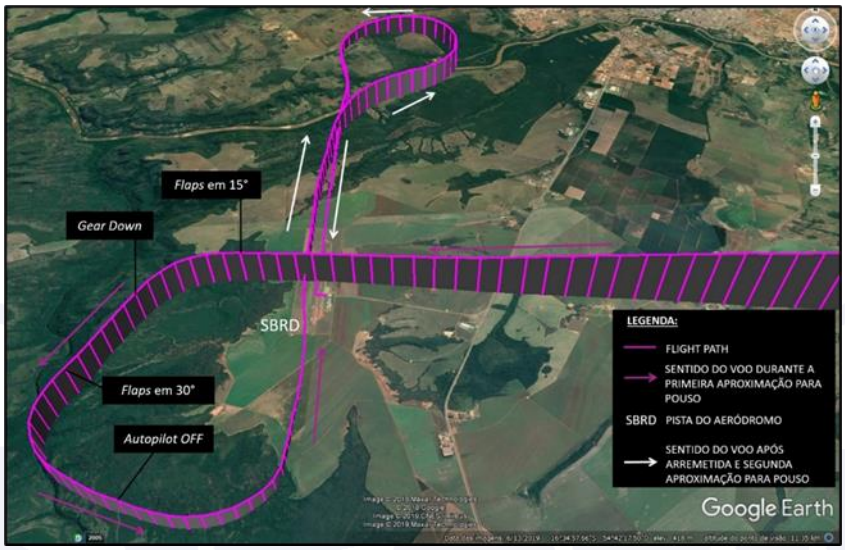

Figure 24 - Aircraft path.
Source: Adapted from Google Earth.

Comparing Figures 22 and 24, there are some differences between the profile defined by the SOP and the one performed by the crew, mainly with regard to the moment of the aircraft configuration for landing and the moment of disconnection of the autopilot.

The Advisory Circular (AC) No. 91-79A, of 17 SEPT2014, published by the FAA, in its Appendix 1, Chapter 3, dealt with stabilized approximations. The Circular highlighted that a stabilized approach was one of the most critical elements for ensuring safety during landing operations.

The letter “b”, from Chapter 3, Appendix 1, of AC 91-79A, which described the profile of a stabilized approach, stated that the optimum angle to be maintained during a final stabilized approach was 3°. Following the document, the letter “c” described that the ideal descent rate for a 3° ramp could be found by multiplying the aircraft's ground speed by five.

> APPENDIX 1. SUGGESTED PROCEDURES AND TRAINING INFORMATION
>
> 1. […]
>
> 2. [...]
>
> 3. STABILIZED APPROACH TO THE TOUCHDOWN AIM POINT.
>
> a. […]
>
> b. Stabilized on Profile. The airplane should be stabilized on profile before descending through the 1,000-ft window or through the 500 ft above TDZ elevation (TDZE) window in visual meteorological conditions (VMC). Configuration, trim, speed, and glidepath should be at or near the optimum parameters early in the approach to avoid distractions and conflicts as the airplane nears the threshold window. The electronic or visual glidepath or an optimum glidepath angle of 3 degrees should be established and maintained. For the purposes of this AC, approaches that require a glidepath angle greater than 3 degrees are a “special case.” The airplane must be in the proper landing configuration, on the correct lateral track, the correct vertical track and at the proper airspeed. It should be noted, as it applies to stabilized approaches, that following lateral and vertical tracks should require only normal bracketing corrections. (our emphasis)
>
> c. Descent Rate. The optimum descent rate for a 3-degree approach path is based upon the airplane’s ground speed. A pilot must exercise discipline and situational awareness to maintain the airplane’s target approach speed. The following is a method to estimate the appropriate descent rate for a 3-degree descent path: Multiplying the ground speed in knots (kts) by 5 provides a usable target 3-degree descent rate in ft per minute. […] (our emphasis)

According to the Flight Safety Foundation (FSF), there are some principles of wide application in aviation that can be significantly useful to pilots. They are called rules of thumb and are a simple way to detect gross errors.

In an article published in its virtual library, on 07DEC2019 << https://www.skybrary.aero/index.php/Rules_of_Thumb >>, the FSF spoke, among other things, about the flight path during an approach ramp end of 3° angle.

The article highlighted that, during a ramp of 3°, the aircraft should descend 300ft for every nautical mile traveled, until it touches the runway. He also emphasized that the ratio between the rate of descent and the aircraft's speed during a 3° ramp should be 1:5.

That is, if an aircraft developed 120kt of indicated speed, the ideal descent rate for it to maintain the 3° ramp would be 600ft/min, also according to the technique described by the AC 91-79A issued by the FSF.

This is because, keeping a speed of 120kt, the aircraft would travel 120 NM in an hour, that is, 2 NM per minute. Thus, keeping a rate of descent 600ft/min and a speed 120kt, the aircraft would descend 300ft for each mile traveled.

The table in Figure 25 was constructed taking into account the rule of multiplying the aircraft's speed by five to find the recommended descent rate for an ideal 3° ramp.

Slope of the ramp	Speed	Rate of Descent	Runway Distance	Height over terrain
3°	120kt	600ft/min	6 NM	1.800ft
3°	120kt	600ft/min	3 NM	900ft
3°	120kt	600ft/min	2 NM	600ft
3°	120kt	600ft/min	1 NM	300ft

Figure 25 - Table of values for a 3° ramp.

The table establishes a relation between the height over terrain and the distance from the runway threshold, for constant values of ramp angle (3°), speed (120kt) and rate of descent (600ft/min).

Specifically, for the ATR-72-212A model, the FCOM, Part 2, Chapter 2, Section 12, Page 5, Revision JUL 01, in the Flight Characteristics chapter, described the maintenance of a 3° ramp during the final approach for landing to a height of 20ft, as a recommended landing technique.

The FCOM said that:

> LANDING
>
> In order to minimize landing distance variations, the following procedure is recommended:
>
> • Maintain standard final approach slope (3°) and final VAPP until 20 ft is called on radio altimeter.
>
> • At «20ft» call by PNF, reduce to FI and flare visually as required.
>
> Note: 20 ft leaves ample time for flare control from a standard 3° final slope.
>
> […] (our emphasis)

Because the 3° ramp is considered ideal during landing approaches, the path developed by the aircraft was compared with an imaginary 3° ramp.

For this comparison, a green line with a 3° angle was drawn from the threshold 02 of the SBRD runway. The magenta line illustrates the trajectory developed by the aircraft, based on data collected by the FDR, as shown in Figures 24 and 26.

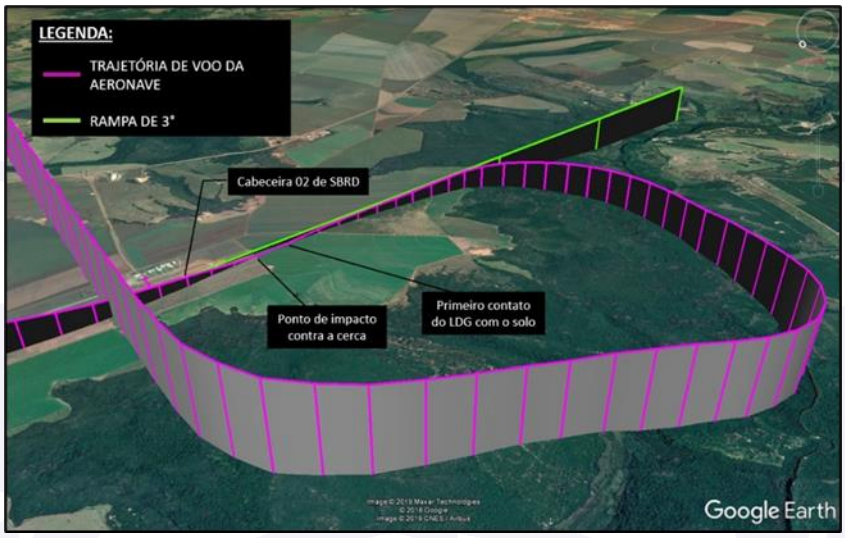

Figure 26 - Top view of the path taken by the aircraft during the traffic circuit.
Source: Adapted from Google Earth.

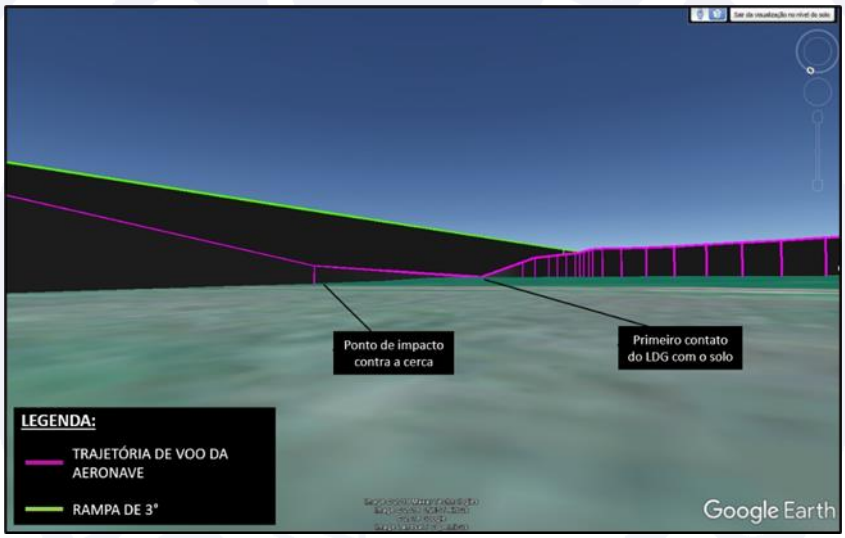

Figure 27 - Side perspective view of the path traveled by the aircraft, compared to the 3° ramp.
Source: Adapted from Google Earth.

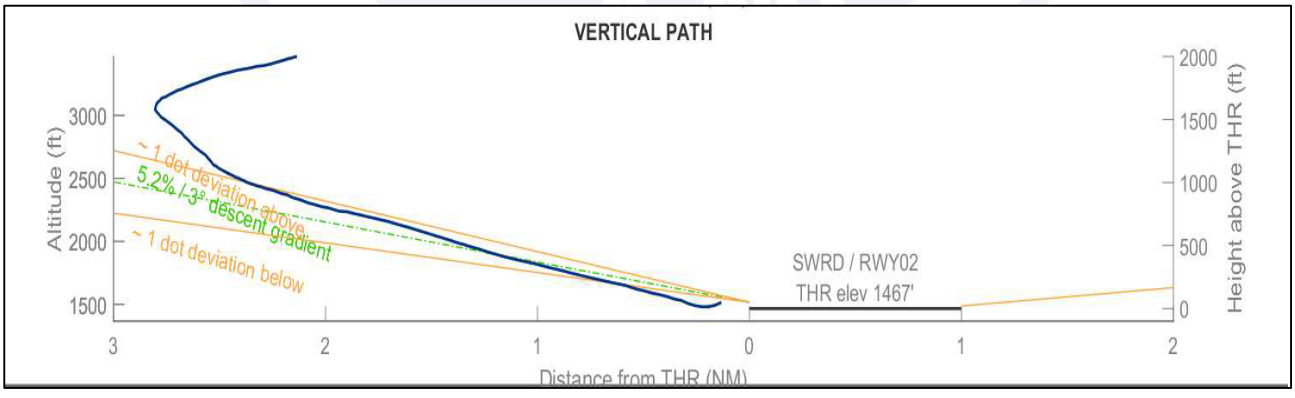

Figure 28 - Vertical path profile. Source: ATR.

Figures 26, 27 and 28 illustrate different perspectives of the ramp developed by the aircraft, in comparison with the 3° ramp, drawn from the threshold 02.

It is noted that, at the beginning of the final approach, the aircraft was above the nominal flight path. Later in the approach the aircraft went below the 3° flight path until 20ft where a go around was initiated.

In an interview, the pilots reported seeing the runway as part of the final approach for landing. They also reported that the aircraft quickly entered a light mist, which impaired the view of the runway for a few seconds, and that, soon after, they saw the Aerodrome again. Finally, they said they did not realize that they were getting below the ramp and approaching the ground.

When crossing 50ft in height, the aircraft's automatic call-out system announced the expression “fifty” on the cockpit speakers twice. Both pilots stated that, just before the call-out sounded, they entered a light fog, making it difficult, but without impeding, the visualization of the runway.

Upon hearing the automatic call-out “fifty”, the copilot commanded the go-around procedure announcing in a high voice “Go Around! Go Around!”.

The pilots started the go-around procedures, but the aircraft continued to descend, coming to touch the ground, approximately, 400m before the runway threshold.

The aircraft traveled 72m over the terrain, colliding with two concrete posts on the Aerodrome's patrimony fence during the path on the ground.

After impacting the fence and touching the ground, the aircraft took off again. The crewmembers repositioned the plane for landing in the opposite direction to the first approach.

When it reached 500ft above the Aerodrome altitude, during the second approach, the aircraft had a descent rate 300ft/min, speed 115kt, magnetic heading at 198°, configured for landing, TLA of the engine throttle # 1 at 55, 55º, torque of engine # 1 in 46.25%, TLA of the throttle of engine # 2 in 54.50º and torque of engine # 2 in 41.75%.

Comparing the two approaches, it is noted that the torque values of the engines and the position of the power levers of the second approach are higher than those recorded during the first approach (Figure 29).

	1st Approach		2nd Approach	
	Engine #1	**Engine #2**	**Engine #1**	**Engine #2**
TLA	41,84º	41,14º	55,55º	54,50º
Tq	14,5%	9%	46,25%	41,75%

Figure 29 - Comparative table of the TLA and Tq parameters of the engines during the two approaches for landing.

The average descent rate during the second approach to landing was approximately 435ft/min, while the first approach was 844ft/min.

The second approach and landing took place without major problems, despite the damage caused to the aircraft due to the impact against the concrete posts during the first approach.

1.19 Additional information.

VISUAL APPROACHES

According to the FSF, although visual approach is one of the first types of approach taught to pilots, this procedure has inherent risks, especially at night and at airports which pilots are not familiar with.

The FSF, in the publication Approach-and-Landing Accident Reduction (ALAR) Briefing Note 7.4, recommended that the following parameters should be carefully considered by pilots before deciding to perform a visual approach procedure, especially at Aerodromes which they are not familiar with:

- visibility and ceiling conditions;
- darkness (lighting level);
- meteorology;
- winds and turbulence;
- rain or snow;
- smoke or fog;
- crew experience at the Aerodrome;
- terrain in the surroundings;
- Aerodrome-specific hazards; and
- visual aids for the runway:
- type of ALS; and
- presence of VASIS or PAPI.

One of the risks inherent to the visual approach at night, brought to light by the FSF publications, are visual illusions.

VISUAL ILLUSIONS

According to the FSF, visual illusions occur when the pilot's eyes are led to make an erroneous assessment of the aircraft's position or orientation in relation to the external environment.

> Illusions occur when conditions modify the pilot's perception of the environment relative to his or her expectations, possibly resulting in spatial disorientation or landing errors (e.g., landing short or landing long).

The ALAR Briefing, Note 5.3, of FSF stated that visual illusions are the result of the absence or alteration of visual references, which modify the pilot's perception of his position (in terms of height, distance and / or intercept angle) in relation to the threshold of the runway. Visual illusions affect the crew's situational awareness, especially during the base leg and the final approach.

> Visual illusions result from the absence of visual references or the alteration of visual references, which modify the pilot's perception of his or her position (in terms of height, distance and/ or intercept angle) relative to the runway threshold.
>
> Visual illusions affect the flight crew's situational awareness, particularly while on base leg and during the final approach.

Visual illusions usually induce corrections on the part of pilots. These corrections, translated into actions on the flight controls, cause the aircraft to deviate from its vertical or horizontal flight path.

Visual illusions usually induce crew inputs (corrections) that cause the aircraft to deviate from the vertical flight path or horizontal flight path.

One of the typical scenarios of visual illusions exemplified by the FSF is precisely when the pilot makes a misjudgment of the height of the aircraft during the final approach, resulting in a touch before the runway threshold.

One of the specific types of visual illusion, considered a risk during nighttime visual approaches by the FSF, is the Black Hole Effect.

BLACK HOLE EFFECT

The Black Hole effect, also called as homogeneous terrain illusion, is a type of visual illusion that induces pilots to falsely perceive themselves to be in a higher position than they actually are, causing them to fly at dangerously low heights, especially during landing approaches.

The conditions for this effect to occur are more common on dark nights (usually without a moon), when there are no lights between the aircraft and the runway threshold.

The FSF pointed out in the text of the ALAR Briefing, Note 7.4, that the runway lights alone are not always sufficient to guarantee a safe visual approach.

Factors such as the runway width can influence the pilots' perception regarding the height of the aircraft in relation to the approach ramp.

Figure 30, extracted from the ALAR Briefing, Note 5.3, illustrates the effect of the runway width on the pilots' height perception during a visual night approach.

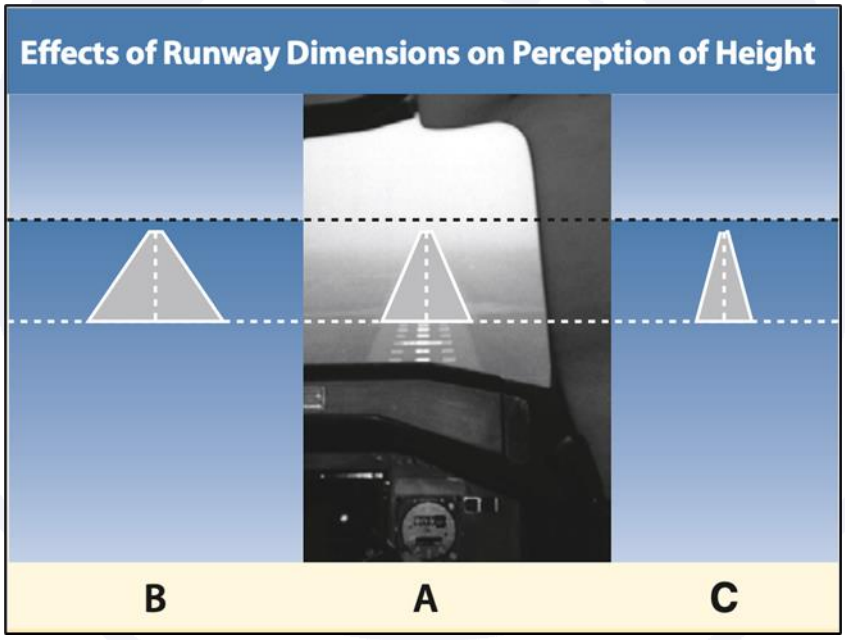

Figure 30 - Influence of the runway width on the pilots' height perception.
Source: Flight Safety Foundation.

The three panels in Figure 30 show the view from inside the cockpit of an aircraft at 200ft in height, on a 3° approach ramp.

The runway of panel A is 45m wide, like most runways at airports that serve regular passenger transport flights in Brazil.

The runway of panel B is wider than the runway of panel A. In approaching to runway B, pilots may have the perception of being on a lower approaching ramp than the one they are actually on.

The runway of panel C is narrower than the runway of panel A. In approaching runway C, pilots may perceive themselves to be on an approaching ramp higher than the one they actually are.

The FSF briefing note also emphasized that the risks inherent to visual illusions may be more critical during approaches for night landing, if there is a decrease in visibility due to low clouds, fog or precipitation.

According to the publication, the presence of light rain, fog, smoke or darkness creates an illusion of being too high in relation to the runway.

The entry into a layer of fog also leads pilots to have an aircraft's pitch up perception. This perception can lead the pilot to correct the situation by acting on the flight controls in the direction of nose down.

According to the FSF, prior preparation and planning are the keys to making a visual approach at night safely.

1.20 Useful or effective investigation techniques.

Nil.

2. ANALYSIS.

It was a passenger transport flight. All crewmembers were qualified. However, it was the first time that the commander would land on SBRD, since he was hired by the operator. The copilot, in turn, had landed another seven times on that location, however, all as a Pilot Monitoring.

The company's MGO defined previous experience parameters only for Aerodromes classified as special. However, SBRD was not considered special, neither by the ANAC nor by the operator. As a result, the operator's manuals did not specify requirements for recent experience for pilots operating in SBRD. Thus, the fact that the commander and the copilot did not have recent experience in the locality, despite being relevant to this accident, did not contradict any provision of the referred manuals.

The flight from SBBR to SBRD was the third leg of the day for that crew and would be carried out entirely at night.

The Maestro Marinho Franco Aerodrome had some peculiar characteristics that were described in the Airport Briefing produced by the operator (Figures 20 and 21).

According to the RBAC 154,305 (j) (1) (i) (B), items (1) and (2), which regulated the installation of visual approach ramp systems, the Aerodrome should have the aids described, however, the ANAC's understanding, explicited in Decision n°134, made it clear that the items cited applied only to airports that did not exist in 12MAY2009 or, for existing ones, in specific cases defined by the Agency.

Thus, it was concluded that the items mentioned above of RBAC 154, Amendment 01, of 12JUN2012, were not applicable to SBRD and that, therefore, the absence of visual approach ramp systems did not contradict the regulations in force at the time of the accident.

However, the Aerodrome's geographic location, associated with the absence of luminous aids and significant artificial light, made the entire terrain around the runway very homogeneous. Thus, there was little or no visual reference that could assist pilots in determining the aircraft's position in relation to the approaching landing ramp.

In addition, the Aerodrome did not have, at the time of the accident, an air traffic control organ, nor an instrument approach procedure. There was, in the locality, an EPTA that provided AFIS service and made messages of the METAR and SPECI types. In this way, the landing and take-off operations were exclusively visual and the decisions about the traffic

circuit and the direction of approach were completely the responsibility of the crewmembers, as long as they complied with the air traffic rules in force and associated with the type of operation.

The meteorological minimums established in the ICA 100-12, in force at the time, for visual operation were 5,000m of horizontal visibility and 1,500ft of ceiling. At the time of preparation for the flight leg between SBBR and SBRD, the last meteorological information from SBRD, which was available for consultation by the crew, was the EPTA closing SPECI, made at 2030 (UTC) on 08JAN2016.

In that SPECI, it was said that the horizontal visibility was above 10,000m and with few clouds at 2,000ft in height. Values above the minimum established for visual operation.

The aircraft took off from SBBR, at 0033 (UTC), on 09JAN2016, with a lag of just over four hours in relation to the last official meteorological information available.

At about 0156 (UTC), the crew made contact with the Rondonópolis Radio, in order to obtain information about the meteorological conditions at the Aerodrome. During this communication, the OAS informally described the current weather conditions. He reported that the SPECI at 0130 (UTC) contained information on very intense fog in the South sector, but that the horizontal visibility was 20km and that the fog was already less dense. Finally, he said that it was not possible to visualize the base of the cloud layer over the Aerodrome.

Despite making comments on the 0130 SPECI (UTC), the OAS did not read the message in its entirety. It is worth mentioning that the SPECI provided information on horizontal visibility equal to 1,000m, presence of fog and vertical visibility equal to 100ft, as highlighted below.

SPECI SBRD 090130Z /////KT 1000 FG VV010 ///// Q1010=

These conditions were below the meteorological minimums for visual operation established by the ICA100-12 and, therefore, constituted information of relevant importance for pilots. However, the crew never took notice of the visibility and ceiling values described in the SPECI message of 0130 (UTC), since the OAS did not read it during communications with the aircraft.

In an interview, the OAS reported that, at the time of this communication with the aircraft, he was able to view the lights of the city of Rondonópolis. Aware that the city was about 20 km from the Aerodrome, he passed on the horizontal visibility information equal to 20 km to the aircraft, despite the fact that the SPECI contained 1,000m.

During the communications, the OAS reported that it was still making the METAR from 0200 (UTC). The fact that the METAR for the next hour was still being made was understandable, since it was about four minutes before 0200 (UTC) and the OAS would have until 0205 (UTC) to send the METAR in force at the time, according to the ICA 105 -1.

Whenever a METAR message was sent outside the window defined by the ICA 105-1, the DECEA database recorded the time at which the message had been transmitted for the purpose of punctuality statistics. Only the delayed messages were recorded in the system. The data relating to the time of sending messages received within the time window defined by the ICA were not recorded.

There was no record in the DECEA database of a delay in sending the METAR from 0200 (UTC) to the SBRD Aerodrome, on 9JAN2016. Although the system did not record the time that the OAS sent METAR to DECEA, it is possible to state that the message was sent within the window established by the ICA 105-1, that is, at 0205 (UTC) at the latest. If the 0200 (UTC) METAR had not been sent on time, the system would have treated the message as delayed and would record its sending time.

Although the OAS verbalized to the PR-PDD, at 0156 (UTC), that the visibility at the Aerodrome was 20km, the METAR at 0200 (UTC), made minutes after the communications with the aircraft, brought a horizontal visibility value equal to 4,000m, as highlighted:

METAR SBRD 090200Z 10007KT 4000 BR SCT007 SCT100 23/23 Q1011=

It is worth mentioning that this value was below the minimum horizontal visibility value for approach operations under visual flight rules defined by the ICA 100-12 (5,000m). Therefore, according to the METAR of 0200 (UTC), the meteorological conditions in SBRD continued to be incompatible with the visual operation.

At 0210 (UTC), already descending to the traffic altitude, the PR-PDD definitively established contact with the Rondonópolis Radio. During communications with the aircraft, the OAS did not read the METAR at 0200 (UTC), which it had prepared minutes before. Again, the EPTA operator carried out an informal description of the meteorological conditions recorded at the time, informing about the presence of fog banks which, according to him, the wind was being able to dissipate. In that communication, the OAS did not comment on the horizontal visibility at the Aerodrome.

It was concluded, therefore, that the crew was not aware of the meteorological conditions described in the METAR at 0200 (UTC), having only the description verbalized by the OAS as a source of information. This information passed by the OAS to the aircraft suggested that the weather conditions in SBRD were favorable for visual flight. For the PR-PDD pilots, there was therefore no restriction on visual operation that night.

Regarding the informality of the messages transmitted by the EPTA operator during communications with the aircraft, it is emphasized that the ICA 105-1 and MCA 100-16, in force at the time of the accident, did not have detailed information regarding the phraseology to be used nor did it oblige the OAS to pass on the information contained in the METAR of the hour to aircraft requesting meteorological information from the Aerodrome.

Even more recent publications such as MCA 100-16 and ICA 100-37 did not contain detailed information regarding the obligation for the OAS to pass on the information contained in METAR to aircraft, nor were they clear about the origin of the information to be transmitted.

At 0213 (UTC), the pilots informed the Radio that they were seeing the Aerodrome and that they were observing the presence of very heavy fog in the North sector of the city of Rondonópolis. The OAS, once again, did not read the METAR of the hour, having made informal comments on the weather, adding that threshold 20 seemed to be in better weather conditions than threshold 02. However, at the end of the transmission, it stressed that the pilots would have better conditions for observing meteorology in flight than it would have on the ground.

The pilots informed that they would proceed to threshold 02, despite the OAS reservation regarding the apparently better conditions at threshold 20. They then performed a standard visual traffic circuit, with turns to the left.

During the traffic circuit, the pilots carried out the configuration of the aircraft for landing at points other than those recommended by the SOP.

The flaps were lowered to 15º on the Aerodrome's crossing axis (perpendicular to the runway), while the SOP established that this procedure should be performed on the wind leg, across the runway's threshold.

The landing gears were lowered close to the threshold’s abeam, before the end of the wind leg. The SOP instructed to perform this procedure at the beginning of the turn for the base leg.

The flaps were lowered to 30º still in the wind leg, while the SOP established that this procedure was carried out only during the base leg.

Finally, the autopilot was disconnected on the base leg, while the SOP established that this procedure should be performed during the final approach, with a guaranteed landing.

Upon entering the final approach ramp, the aircraft was in the following conditions:

- altitude: 2,100ft (633ft in relation to the runway);

- distance from the runway: 1.9 NM;

- indicated speed: 124kt;

- ground speed: 118kt;

- descent rate: 1,080ft / min;

- landing gear: down; and

- flaps: 30°.

According to the FSF and FAA studies, maintaining a ramp trajectory with an angle of 3°, at an approximate speed of 120kt, an aircraft should be 600ft high, when at a distance of 2 NM from the runway. The PR-PDD was 633ft high, 1.9 NM away from the runway, so it was in a condition very close to the ideal.

However, it is clear that the descent rate of 1,080ft/min was high, compared to the ideal rate of descent of 600ft/min, for the speed being maintained by the aircraft (Figure 25).

The MGO specified that the aircraft should be in a condition compatible with that of stabilized approach when reaching a height of 500ft above the Aerodrome. When it reached that point of approach, the aircraft was in the following conditions:

- altitude: 1,967ft (500ft in relation to the runway);

- distance from the runway: 1.6 NM;

- indicated speed: 123kt;

- TLA engine #1: 41.84°;

- Tq engine #1: 14.5%

- TLA engine #2: 41.14°;

- Engine #2: 9%;

- descent rate: 960ft/min;

- landing gear: down; and

- flaps: 30°.

Following the parameters defined for an approach stabilized by the MGO, it is clear that the aircraft was in the flight path, at the appropriate speed and configuration for landing. However, the power adjustment was reduced (engine #1 41.84°; engine #2 41.14°), with values close to the flight idle range (37° TLA) and with a rate of descent above the ideal.

During the final approach, the aircraft started to fall below the ideal 3° ramp without the pilots realizing it. The average rate of descent, during the final approach, was 844ft/min. This value was above the 600ft/min recommended by the FSF for a 3° ramp when maintaining 120kt of indicated speed (Figure 25).

In addition to the lack of accurate meteorological information, some factors contributed to the pilots not realizing that the aircraft was approaching the ground, in a position still distant from the runway threshold.

The first one was the dark night, due to the absence of the moon. On the night of the occurrence, the moon had set at 1833 (UTC-2), on 08JAN2015, and its rise took place only at 0617 (UTC-2), on 9JAN2015. Therefore, at the time of approaching and landing the aircraft, the night had no moon, and can therefore be considered a dark night. According to the FSF studies, dark nights can lead pilots to experience an illusion of being too high in relation to the runway.

The second important factor was the presence of fog banks in the South sector of the Aerodrome. The crew members reported having entered one of these fogs momentarily, during the final approach, making it difficult to visualize the runway. The fog banks, in addition to influencing the horizontal visibility and the ability of the pilots to see the runway, can contribute to the appearance of a visual illusion, making the pilots have the false perception of being very high in relation to the Aerodrome, everything according to the FSF.

The runway width was the third relevant factor. The SBRD runway was 30m wide. It was therefore narrower than most of the runways on which scheduled airlines operate normally. It was even narrower than the SBBR runway, a destination prior to landing in SBRD for that crew. The FSF states, in its articles, that narrower runways can give pilots the feeling of being on an approaching ramp higher than the one they actually are.

The location and airport infrastructure characteristics of the SBRD runway are the fourth important factor. The environment in which the runway was located was quite homogeneous, surrounded by soybean plantations and without any significant source of lighting other than the runway's marking lights.

In addition, the Aerodrome had no aid of the ALS, VASIS or PAPI types. These visual aids would serve as a reference for pilots to determine the aircraft's position in relation to the ideal ramp for the runway, thus preventing them from falling below the ideal ramp without realizing it.

The fifth and last factor considered was the rate of descent above the ideal, which implied a reduction in power in order to maintain the approach speed.

Approaching for landing at an Aerodrome that they were not familiar with, on a narrower than usual runway, through a sector with homogeneous terrain characteristics, in a dark night, without a moon, without light sources between the aircraft and at the end of the runway and without accurate meteorological information, the crewmembers were placed in a context favorable to the appearance of visual illusions, especially the Black Hole effect.

The Black Hole effect is a type of visual illusion that induces pilots to the false perception of being in a higher position than they actually are, causing them to fly at dangerously low heights, especially during landing approaches.

In these conditions, it is feasible to assume that the pilots acted on the aircraft's controls, in order to correct their position in relation to the false perception of being high on the ramp, including the fact of maintaining a reduced power adjustment. The results of these actions led the aircraft to follow a flight path below the ideal ramp of 3° during the approach for landing in SBRD.

When crossing 50ft in height over the terrain, the aircraft's automatic call-out system announced “fifty”. At that moment, the copilot realized that the aircraft was very close to the ground and commanded the go-around procedure announcing: “Go Around! Go Around!”. The commander initiated the procedure, carrying out the planned actions, among them applying power. However, the aircraft continued to descend, touching the ground about 400m before the runway. It is likely that the reduced power adjustment has influenced the response of the aircraft's engines and contributed to the aircraft continuing to descend to the point of touching the ground.

The fact that the pilots reacted to the condition of proximity to the ground, only after the aircraft's automatic call-outs system announced that they were 50ft high, showed that the flight management between them was not adequate, compromising the quality of their flight conduction and its monitoring, particularly in relation to a basic parameter of visual flight such as the height/distance of the aircraft in relation to the runway. Under suitable conditions, it would have been possible to start a run at an earlier time, which would allow the procedure to be carried out without the aircraft touching the ground.

Thus, although the pilots' performance was considered satisfactory for the items related to CRM in the last simulator training to which they were submitted, it was concluded that in the accident flight, the coordination of cabin resources was not performed properly, contributing to this occurrence.

After touching the ground, the plane still covered a distance of 72m on the ground before taking off again. In that way, he collided with two concrete posts on the Aerodrome's patrimony fence.

The pilots completed the Go Around procedure, gaining height again and repositioning the aircraft for landing in the direction of threshold 20, contrary to the approach that had just been carried out.

During the second approach, the power adjustment parameters were significantly higher than those kept on the first landing attempt.

The second landing procedure was completed successfully.

All occupants left unharmed.

3. CONCLUSIONS.

3.1 Facts.

a) the pilots had valid CMAs;

b) the pilots had valid AT47 and IFRA Ratings;

c) the pilots were qualified and had experience in the kind of flight;

d) it was the first time the commanded landed on that location;

e) the aircraft had valid CA;

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

g) the aircraft's technical maintenance records were updated;

h) the meteorological conditions were below the minimum for visual operation;

i) the OAS provided an informal description of the meteorological conditions recorded, informing values of horizontal visibility higher than those described in the SPECI at 0130 (UTC) and in the METAR at 0200 (UTC);

j) the pilots did not have access to the information contained in the SPECI and the METAR messages published at 0130 (UTC) and 0200 (UTC), respectively;

k) the pilots spotted the airfield and started the standard visual traffic circuit for the SBRD threshold 02, with turns on the left;

l) during the final approach, the aircraft traveled a trajectory below the ideal ramp of 3º of inclination;

m) when crossing 50ft in height, the aircraft's automatic call-out system announced “fifty”;

n) the copilot commanded the go-around procedure;

o) the pilots started the procedure, but the plane touched the ground before the runway, covering a distance of 72m over a soybean plantation;

p) during the trajectory on the ground, the aircraft collided with two concrete posts on the Aerodrome's patrimony fence;

q) the pilots completed the go-around procedure and repositioned the plane for landing in the direction of the threshold 20;

r) the final landing took place without abnormalities;

s) the aircraft had substantial damage; and

t) all occupants left unharmed.

3.2 Contributing factors.

- **Control skills – a contributor.**

When subjected to the effects of visual illusions during the final approach for landing, the pilots had the false perception of being high on the ramp, acting on the flight controls in order to correct their position in relation to the false perception. The inadequate performance of the controls led the aircraft to be excessively close to the ground, still about 400m from the Aerodrome. This condition had the consequence of touching the ground before the head of the threshold.

- **Adverse meteorological conditions – a contributor.**

The presence of fog at the Aerodrome, as well as reduced horizontal visibility, contributed to the pilots being subjected to visual illusions during the final approach for landing.

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

Despite the physical characteristics of the Aerodrome and the associated meteorological phenomena, the pilots were able, by monitoring basic flight instruments, to determine the height and distance of the aircraft in relation to the runway to which they were making the approach.

The fact that the pilots reacted to the condition of proximity to the ground, only after the aircraft's automatic call-outs system announced that they were 50ft heigh, showed that the flight management between them was not adequate, compromising the quality of their flight conduction and its monitoring, particularly concerning a primary parameter of the visual flight such as the height of the aircraft. If the CRM and the workload distribution were adequate, pilots would recognize the proximity to the terrain earlier, and it would have been possible to start a Go Around procedure without the aircraft touching the ground.

Thus, it was concluded that, in the accident flight, the coordination of cabin resources was not performed properly, contributing to this occurrence.

- **Use of phraseology by ATS – a contributor.**

The informality with which the OAS carried out communications with the aircraft prevented the crewmembers from having access to relevant factual information from the SPECI at 0130 (UTC) and the METAR at 0200 (UTC). In addition, the significant difference between the values contained in the formal meteorological messages (SPECI and METAR) and the informal description transmitted via radio, showed inadequacy in the formulation of messages by the OAS of the Rondonópolis Radio.

The fact that the crew was not clearly informed about the visibility conditions contained in the METAR from 0200 (UTC) affected their level of situational awareness and compromised the decision-making capacity, since visibility values below the minimum

established in the ICA 100-12 could lead pilots to decide not to perform the visual landing procedure in SBRD.

- **Illusions – a contributor.**

The operation at an Aerodrome in which pilots had little or no recent experience, with a narrower runway than they had previously landed, in a sector with homogeneous terrain characteristics, in a dark night, without moon, without sources of light between the aircraft and the runway threshold and without accurate meteorological information constituted a favorable scenario for the emergence of visual illusions, especially the Black Hole effect.

This visual illusion led pilots to the false perception of being in a higher position than they actually were, causing them to fly at a very low altitude, culminating in a flight path below the ideal 3° ramp, which resulted in touching the ground 400m before the runway.

- **Airport infrastructure – a contributor.**

The physical characteristics of the Aerodrome, especially the absence of luminous visual aids for approaches (ALS, VASIS, PAPI), contributed to the crew not realizing that the aircraft was traveling a flight path below the ideal 3°ramp. Although the operation without aid of the ALS, VASIS and / or PAPI types is in accordance with the regulations in force for visual night operation, the presence of such aid increases the situational awareness of pilots and is reflected in a significant contribution to flight safety during nighttime visual approaches.

- **Piloting judgment – a contributor.**

Despite the Aerodrome's physical characteristics, the pilots had their judgment to determine the aircraft's position in relation to the 3° ramp. During visual approach operations, it is the pilots' responsibility to provide separation of the aircraft from obstacles and other aircraft in flight. That way, pilots should have been able to realize that they were below the ideal 3° ramp before the aircraft got too close to the ground.

The pilots' inadequate assessment of the aircraft's position in relation to the 3° ramp and the runway contributed to the aircraft touching the ground 400m before the runway.

- **Management planning – undetermined.**

The qualification, experience and crew pairing criteria defined in the MGO did not require previous experience for operating in SBRD. This way, it was scheduled a commander who had never operated in the locality with a copilot who, despite having landed on that Aerodrome seven times before the accident, had never operated on the aircraft's controls.

Although it does not contradict any regulations in force, the pairing of pilots for an Aerodrome with operational restrictions/recommendations, such as those contained in the Airport Briefing of SBRD, may have represented an inadequate management of available human resources.

- **Insufficient pilot’s experience – a contributor.**

The pilots' little experience in that location contributed to them not paying attention to the physical characteristics and, also, to the presence of fog, a meteorological phenomenon typical of that region in January.

- **ATS publication– undetermined.**

The publications dealing with the dissemination of meteorological information (ICA 105-1) and air traffic phraseology (MCA 100-16), in force at the time of the accident, did not have guidelines regarding the phraseology to be used by the OAS when passing on

meteorological information to aircraft, as well as the obligation to pass on the information contained in the METAR of the hour.

The absence of specific phraseology procedures and guidelines may have contributed to the informality of communications observed in this accident.

- **Support systems – undetermined.**

The SBRD's Airport Briefing noted that the Aerodrome was subject to Black Hole at both thresholds. However, there was no description of piloting techniques in the operator's manuals associated with preventing the effects of this visual illusion on flight. Thus, it was concluded that the publications, made available by the operator, were incomplete with regard to the risks associated with the visual illusion of Black Hole and may have contributed to the accident, since the pilots did not have theoretical references that would allow them to know the effect, nor to prevent the risks of this illusion to 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-005/CENIPA/2016 - 01 Issued on 11/16/2021

Work with the operator to improve the management of the pilots schedule intended to operate at Aerodromes with operational restrictions/recommendations and that require exclusive operation by the commander on the landing, in order that they have recent experience and are familiar with the location, especially when the operational recommendations include the possibility of visual illusions, especially of the Black Hole effect type.

A-005/CENIPA/2016 - 02 Issued on 11/16/2021

Work with the operator, in the sense that the manuals, internal documentation and Airport Briefings contemplate the possible risks associated with the night visual operation and visual illusions, describing the phenomena and detailing piloting techniques associated with the prevention of the risks that these illusions may represent to the flight, especially in Aerodromes without visual aid for approaches (ALS, VASIS, PAPI, etc.).

A-005/CENIPA/2016 - 03 Issued on 11/16/2021

Work with the operator, in the sense that, in the initial and recurrent training of their pilots, the division of tasks is emphasized during night visual approaches, especially with regard to the monitoring of the altitude and distance parameters of the runway as a function of the indicated speed, in order to make it possible to maintain an adequate approach ramp.

A-005/CENIPA/2016 - 04 **Issued on 11/16/2021**

Work with the operator, in the sense that, in the initial and recurrent training of their pilots, the identification of conditions that are favorable for the appearance of visual illusions is emphasized, as well as in the respective piloting techniques to be adopted, in order to mitigate risks that these illusions pose to the flight.

To the Air Space Control Department (DECEA):

A-005/CENIPA/2016 - 05 **Issued on 11/16/2021**

Assess the possibility of reinforcing the mandatory transfer of meteorological information updated by the OAS, as provided for in that agency's normative publications (MCA 100-16), to aircraft in flight that are taking off or landing in locations without the ATS control agencies.

5. CORRECTIVE OR PREVENTATIVE ACTION ALREADY TAKEN.

In September 2016, the DECEA published a Chart of Approach for RNAV-type Instruments (GNSS) for the SBRD locality.

In 2016, a PAPI equipment was installed at the SBRD threshold 02, and the approval flight was carried out on 16SEPT2016.

On November 16th, 2021.

ANNEX A – COMMENTS BY THE STATES PARTICIPATING IN THE INVESTIGATION

In compliance with the provisions of the Chapter 6, item 6.3, of the Annex 13 to the Convention on International Civil Aviation, the States participating in this investigation had the opportunity to make their comments concerning the content of this final report.

Through the Bureau d'Enquêtes et d'Analyses pour la Sécurité de l'Aviation Civile (BEA), France forwarded the document V-21/21, containing comments from the aircraft manufacturer's ATR.

All comments deemed pertinent have been included in the body of this report. The following are comments that have not been incorporated or have been partially incorporated.

COMMENT 2

Text to be corrected (Chapter 1, Page 7, Lines 9-11)

The crewmembers performed a night visual approach procedure for threshold 02 of the SBRD runway. During the procedure, the pilots crossed the Aerodrome, vertically from the center of the runway, starting a standard traffic circuit, with turns on the left.

Text proposed by the BEA

The crewmembers performed a night visual approach procedure for threshold 02 of the SBRD runway. During the procedure, the pilots crossed the Aerodrome, vertically from the center of the runway, integrating the visual pattern directly in the end of downwind.

CENIPA's Opinion

Not incorporated.

CENIPA's Argumentation

According to the information obtained in this investigation, the entry into the SBRD traffic circuit occurred at the midpoint of the downwind leg, which is in accordance with the Brazilian legislation, as can be seen in the following excerpt from the ICA 100-37/2020 - Air Traffic Services, page 277, item 2:

> 2 ENTRY INTO THE AERODROME CIRCUIT WITH AFIS
>
> 2.1 Alternatively to what is specified in 1.1.4, in order to give greater flexibility to aircraft at Aerodromes provided with AFIS, since bilateral communication is mandatory and the pilot has ensured, with the AFIS provider, that there will be no conflict with another traffic entering or evolving in the circuit, the aircraft may also enter the circuit (Figure 1): a) aligned with the beginning of the downwind leg; b) at the midpoint of the downwind leg, in a direction making 45 degrees in relation to the runway axis; or c) in line with the base leg. NOTE: In these cases, for entry, the aircraft must be in level flight at the circuit altitude, and this altitude must be maintained until the descent for landing.
>
> 2.2 If there is no other traffic and if the crew is familiar with the Aerodrome, an aircraft, if flying VFR, may directly enter the final leg or, if flying IFR, may make a direct approach.

COMMENT 5

Text to be corrected (Chapter 2, Page 60, Line 2)

Then, the aircraft turned to the left, starting a standard visual traffic circuit.

Text proposed by the BEA

Then, the aircraft turned to the left, integrating the visual pattern through end of the downwind.

CENIPA's Opinion

Not incorporated.

CENIPA's Argumentation

According to the argumentation in the Comment 2.

COMMENT 6

Text to be corrected (Chapter 1, Page 29, Lines 15-16)

...TLA of the power lever of engine # 2 in 41.14º and torque of engine # 2 in 9%.

Text proposed by the BEA

...TLA of the power lever of engine # 2 in 41.14º and torque of engine # 2 in 9%. The lateral mode was probably LNAV mode while the vertical VS mode was used. The VS target for the final approach was -900ft/min.

CENIPA's Opinion

Not incorporated.

CENIPA's Argumentation

The addition of the leg suggested by the ATR was not considered relevant to this investigation and could raise doubts, considering that the flight was being conducted manually, as the Autopilot (AP) had been disengaged (OFF) since the middle of the base leg.

COMMENT 10

Text to be corrected (Chapter 2, Page 40, Lines 29-30)

...a flight path below the ideal ramp of 3° during the approach for landing in SBRD.

Text proposed by the BEA

...a flight path below the ideal ramp of 3° during the approach for landing in SBRD. During the base turn, the wind increase significantly from 7kt to 26kt wind from the 86°, which corresponds to 15kt headwind. This sudden unexpected wind change may have contributed to destabilize the flight path.

CENIPA's Opinion

Not incorporated.

CENIPA's Argumentation

According to the analyses carried out in this investigation, the increase in the headwind intensity was not considered relevant for the aircraft to touchdown before the runway.

COMMENT 11

Text to be corrected (Chapter 2, Page 41, Lines 5-6)

The pilots completed the run, gaining height again and repositioning the aircraft for landing in the direction of threshold 20, contrary to the approach that had just been carried out.

Text proposed by the BEA

ATR suggests to detail more the second approach.

CENIPA's Opinion

Not incorporated.

CENIPA's Argumentation

The details suggested by the ATR were not considered relevant for this investigation, considering that the second landing was performed safely.

COMMENT 13

Text to be corrected (Chapter 3, Page 41, Line 32)

3.1 Facts

Text proposed by the BEA

Proposal to add the wind change and the flight path monitoring as they may have contributed to destabilize the final approach path.

CENIPA's Opinion

Not incorporated.

CENIPA's Argumentation

As described in the argumentation to Comment 10, according to the analyses carried out in this investigation, the increase in headwind intensity was not considered a contributing factor to the touch of the aircraft before the runway.

COMMENT 14

Text to be corrected (Chapter 3, Page 42, Line 12)

- Adverse meteorological conditions – a contributor

Text proposed by the BEA

Proposed additional wording: The wind change may have contributed to the destabilization of the approach path.

CENIPA's Opinion

Not incorporated.

CENIPA's Argumentation

As described in the argumentation to Comment 10, according to the analyses carried out in this investigation, the increase in headwind intensity was not considered a contributing factor to the touch of the aircraft before the runway.

COMMENT 15

Text to be corrected (Chapter 3, Page 42, Line 24)

- Crew Resource Management – a contributor.

Text proposed by the BEA

ATR agrees with the content of the paragraph. However, we would like to see more in details what is written in the airline operating manual regarding vertical path monitoring.

CENIPA's Opinion

Not incorporated.

CENIPA's Argumentation

Pages 29, 30 and 31, as well as Figures 22 and 23, describe the main standardized procedures by the company for carrying out approaches under visual flight rules and bring all the information considered relevant for this investigation. In any case, the CENIPA forwarded to the aircraft manufacturer the operator's SOP containing more details on the monitoring of the vertical trajectory in the visual descent procedures, as requested.