COMANDO DA AERONÁUTICA

CENTRO DE INVESTIGAÇÃO E PREVENÇÃO DE ACIDENTES AERONÁUTICOS

FINAL REPORT
IG - 146/CENIPA/2017

OCCURRENCE:	**SERIOUS INCIDENT**
AIRCRAFT:	**PR-GXW**
MODEL:	**737-8EH**
DATE:	**18NOV2017**

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 18NOV2017 serious incident with the 737-8EH aircraft, registration PR-GXW. The serious incident was classified as “[RE] Runway Excursion / Overshoot”.

The aircraft’s crew made a landing approach towards runway 32 of the Cataratas Aerodrome (SBFI), located in Foz do Iguaçu - PR.

During the run after landing, the aircraft overpassed the limits of runway 32 and stopped at the stopway, located after the threshold of runway 14.

The aircraft was not damaged.

All occupants left unharmed.

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

CONTENTS

GLOSSARY OF TECHNICAL TERMS AND ABBREVIATIONS

ADC	Aerodrome Chart
AFM	Airplane Flight Manual
ANAC	Brazil's National Civil Aviation Agency
APP-FI	Foz do Iguaçu Approach Control
CA	Airworthiness Certificate
CATRE	Tactical Applications and Crew Recomplement Center
CB	Cumulonimbus
CENIPA	Aeronautical Accident Investigation and Prevention Center
CMA	Aeronautical Medical Certificate
CVR	Cockpit Voice Recorder
FCOM	Flight Crew Operations Manual
FCTM	Flight Crew Training Manual
FDR	Flight Data Recorder
FL	Flight Level
FMC	Flight Management Computer
FSM	Flight Standards Manual
GPS	Global Positioning System
IAM	Annual Maintenance Inspection
ICAO	International Civil Aviation Organization
IFR	Instrument Flight Rules
IFRA	Instrument Flight Rating - Airplane
INFRAERO	Brazilian Airport Infrastructure Company
LABDATA	Flight Data Recorders Read-out and Analysis Laboratory
METAR	Meteorological Aerodrome Report
NTSB	National Transportation Safety Board (USA)
PF	Pilot Flying
PLA	Airline Pilot License - Airplane
PM	Pilot Monitoring
PN	Part Number
PPR	Private Pilot License – Airplane
RBAC	Brazilian Civil Aviation Regulation
RNAV	Area Navigation
RS	Safety Recommendation
SBCT	ICAO Locator Designator - Afonso Pena Aerodrome, Curitiba- PR
SBFI	ICAO Locator Designator – Cataratas Aerodrome, Foz do Iguaçu - PR
SBGL	ICAO Locator Designator - Antônio Carlos Jobim - Galeão Aerodrome, Rio de Janeiro - RJ

SN	Serial Number
SPECI	Selected Special Aeronautical Weather Report
STAR	Standard Instrument Arrival
TAF	Terminal Aerodrome Forecast
TCU	Towering Cumulus
TPR	Aircraft Registration Category of Regular Public Transport
TSRA	Thunderstorm followed by Rain
TWR-FI	Foz do Iguaçu Aerodrome Tower Control - PR
TWY	Taxiway
UTC	Universal Time Coordinated
VRF	Visual Flight Rules
Vref	Reference Landing Speed

1. FACTUAL INFORMATION.

Aircraft	**Model:** 737-8EH **Registration:** PR-GXW **Manufacturer:** Boeing Company	**Operator:** GOL Airlines S/A
Occurrence	**Date/time:** 18NOV2017 - 0247 UTC **Location:** SBFI **Lat.** 25°36'01"S **Long.** 054°29'06"W **Municipality – State:** Foz do Iguaçu - PR	**Type(s):** [RE] Runway Excursion **Subtype(s):** Overshoot

1.1 History of the flight.

The aircraft took off from the Afonso Pena Aerodrome (SBCT), in Curitiba - PR, to the Cataratas Aerodrome (SBFI), in Foz do Iguaçu - PR, at 0137 (UTC), in order to transport personnel, with 6 crewmembers and 119 passengers on board.

The crew performed the Area Navigation procedure (RNAV) for landing on runway 32 of SBFI.

It was raining at the time of the approach and the prevailing wind had tail component for operation on runway 32.

During the run after landing and deceleration, the aircraft overpassed the limit of runway 32 and stopped at the stopway, located after the threshold of runway 14.

The crew performed the taxiing to the parking area normally.

The aircraft was not damaged. All occupants were unharmed.

1.2 Injuries to persons.

Injuries	Crew	Passengers	Others
Fatal	-	-	-
Serious	-	-	-
Minor	-	-	-
None	6	119	-

1.3 Damage to the aircraft.

There was no damage to the aircraft.

1.4 Other damage.

None.

1.5 Personnel information.

1.5.1 Crew's flight experience.

Hours Flown		
	Pilot	Copilot
Total	25.932:00	6.826:55
Total in the last 30 days	72:12	70:55
Total in the last 24 hours	02:57	02:57
In this type of aircraft	10.009:02	1.683:56
In this type in the last 30 days	72:12	70:55
In this type in the last 24 hours	02:57	02:57

N.B.: The data related to the flown hours were obtained through a consultation to the operator.

1.5.2 Personnel training.

The pilot took the CATRE course, in Natal – RN, in 1975.

The copilot took the PPR course, in the Passo Fundo Aerodrome – RS, in 1995.

1.5.3 Category of licenses and validity of certificates.

The pilot had the PLA License and had valid type and IFRA Ratings.

The copilot had the PLA License and had valid type and IFRA Ratings.

1.5.4 Qualification and flight experience.

The pilots were qualified and had experience in that kind of flight.

1.5.5 Validity of medical certificate.

The pilots had valid CMAs.

1.6 Aircraft information.

The aircraft, serial number 39640, was manufactured by the Boeing Company in 2014 and it was registered in the TPR category.

The aircraft had a total of 11.700 hours and 57 minutes of flight at the time of the occurrence.

The aircraft had valid Airworthiness Certificate (CA).

The technical records were updated.

The last inspection of the aircraft, the "Check A" type was performed on 14NOV2017, by the GOL Airlines S.A. maintenance organization, in Rio de Janeiro - RJ, having flown 42 hours and 58 minutes after the inspection.

1.7 Meteorological information.

The Local Meteorological Bulletins (METAR) of the Cataratas Aerodrome, in Foz de Iguaçu - PR (SBFI), provided the following information:

METAR SBFI 172300Z 16005KT 9999 -TSRA FEW030CB OVC100 23/23 Q1004=

METAR SBFI 180000Z 14006KT 9999 -TSRA FEW030CB OVC100 23/22 Q1004=

TAF SBFI 172130Z 1800/1824 36007KT 9999 SCT025 TN20/1808Z TX28/1818Z PROB40 TEMPO 1800/1810 26010G25KT 4000 TSRA BR BKN010 FEW035CB BECMG 1810/1812 18008KT SCT030 PROB30 TEMPO 1817/1820 VCSH SCT025 FEW035TCU RMK PER=

METAR SBFI 180100Z 18004KT 9999 -TSRA FEW020 FEW030CB OVC100 22/22 Q1006=

SPECI SBFI 180140Z 20005KT 2100 -TSRA BKN004 SCT030CB OVC100 22/22 Q1007=

METAR SBFI 180200Z 18007KT 2000 -TSRA BKN005 FEW030CB OVC100 22/22 Q1006=

SPECI SBFI 180220Z 19008KT 2000 +TSRA BKN004 SCT030CB OVC100 22/22 Q1006=

It was raining on SBFI and the runway was wet when the aircraft landed.

1.8 Aids to navigation.

All navigation and landing aids were operating normally at the time of the aircraft approach

.

1.9 Communications.

All communications between the aircraft and the air traffic control occurred without abnormalities.

In order to facilitate the understanding of the operational context of the occurrence, the parts of the communications recorded by the Cockpit Voice Recorder (CVR) that had relevance were mentioned in the item "1.18 Operational Information", because they are directly related to the parameters of the aircraft operation and assist in the understanding of the incident dynamics.

1.10 Aerodrome information.

The Aerodrome was public, operated by the INFRAERO and operated under visual flight rules (VFR) and by instrument (IFR), both day and night.

The runway was made of asphalt, with thresholds 14/32, dimensions of 2,195m x 45m, with elevation of 787ft. Threshold 32 had 786ft of altitude and threshold 14 had 732ft of altitude. The difference between the thresholds was 54ft, which represented 0.75% negative slope (declivity) from threshold 32 to 14.

The runway had two asphalt stopways located after each of them. The stopway located after threshold 14 had dimensions of 50m x 45m. The stopway located after threshold 32 had dimensions of 60m x 45m.

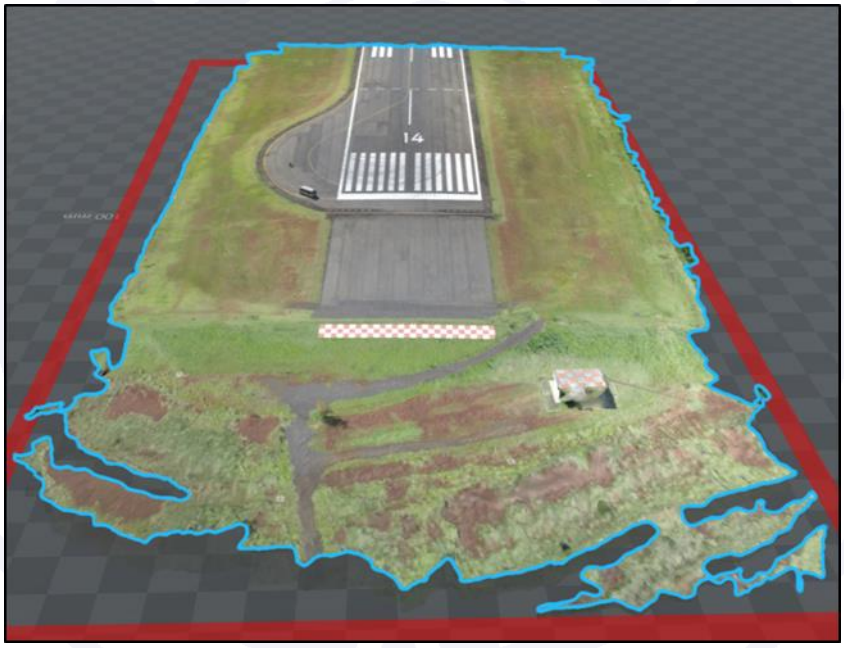


Figure 1 - 3D mapping of the stopway located after threshold 14.

The last runway friction coefficient measurement was performed at 07SEPT2017 and the last macro texture measurement was performed on 10AUG2017. The friction and macro texture measurements were made in accordance with the provisions of RBAC 153 (Amendment 01); Annex 14 of the International Civil Aviation Organization (ICAO) (Volume 1); MP 22.04 / A.

According to the friction measurement report, runway 14/32 SBFI was rated "A> Maintenance Level", which does not require any corrective action. Also, according to the macro texture measurement report, there were no stretches of runway 14/32 SBFI with average depth of macro texture below the normative minimums.

1.11 Flight recorders.

The aircraft was equipped with a Flight Data Recorder (FDR) model HFR5-D, P / N 980-4750-009, S / N FDR-02833, and with a Cockpit Voice Recorder (CVR) model HFR5-V, P / N 980-6032-001, S / N CVR-02756, both manufactured by Honeywell.

The voice and data recorders were sent to the CENIPA's LABDATA, where the data was successfully downloaded.

Both equipment operated normally and contained the flight incident data.

1.12 Wreckage and impact information.

The aircraft overpassed the limits of runway 32, crossing the opposite threshold (14) and stopping at the stopway (50m x 45m).

All tires on the aircraft were inspected. They had a good state of preservation, with deep grooves, with no accentuated wear on the rubber and no apparent plies. No marks were found on the tires that indicated the occurrence of hydroplaning.

Figure 2 – Tires of the aircraft's nose landing gear.

Figure 3 - Tires of the aircraft's left main landing gear.

Figure 4 - Tires of the aircraft's right main landing gear.

The brake sets of the two main aircraft landing gears were checked. The wear check parameters of both brake sets were far from the maintenance limit.

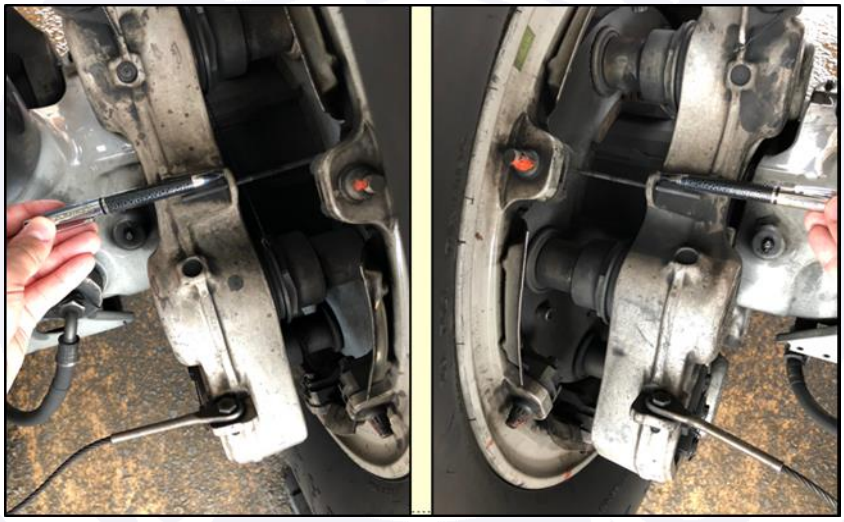


Figure 5 - Brake assembly of the right main landing gear (internal and external).

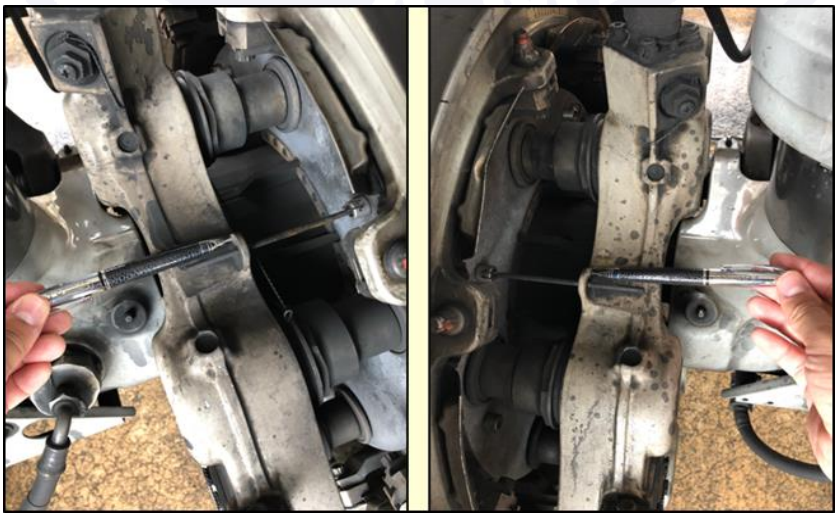


Figure 6 - Brake assembly of the left main landing gear (internal and external).

1.13 Medical and pathological information.

1.13.1 Medical aspects.

Not investigated.

1.13.2 Ergonomic information.

Nil.

1.13.3 Psychological aspects.

The pilots who were part of the flight crew in which the serious incident occurred flew together for the first time. Despite this, they reported having established an adequate team dynamics in the cabin, with coherent and effective communication flow for the operation performed.

According to the pilots, it rained heavily on the route between SBCT and SBFI, which led to many detours en route.

On this flight, the commander assumed the role of Pilot Monitoring (PM) and the co-pilot was the Pilot Flying (PF). The pilots on the flight adopted this same configuration on a flight prior to the incident, referring to leg SBGL - SBCT.

As reported by the commander, despite the rain and wet runway information at SBFI, he judged that the operation occurred normally and therefore felt safe for the accomplishment of the flight and the landing at the destination.

Despite the en route deviations, the pilots reported that they had configured the aircraft for landing normally, with no overloading of tasks during the final approach phase.

According to the report of the copilot, this would be the first time he would make a landing in rainy and wet conditions, as they showed in SBFI in the role of Pilot Flying. Still, according to the commander, he felt comfortable leaving this phase of the operation under the copilot's command, mainly because of the good performance presented by him on the previous flight (SBGL - SBCT).

The copilot, in turn, reported having felt motivated to complete the landing, even aware of the adverse conditions and at the same time new to him in a real condition of operation. According to him, the landing would have become a personal challenge to be overcome, above all by the confidence that the commander placed on him.

During the approach to the landing, the copilot thought to perform a go around procedure. However, because of the commander's confidence in the possibility of the landing, of already being visual with the runway, with the perception of light rain and because of the fact that an aircraft of another airline had landed minutes before, the copilot decided to continue.

Both pilots reported that the runway was dark. The copilot, in particular, reported experiencing difficulties in visualizing it, so he felt insecure that he was with the depth perception impaired. In his own words, he could not see exactly "where the ground was."

For this reason, coupled with the feeling that the aircraft's descent rate was high, and in order to avoid a hard landing, the copilot reported having "held" the aircraft further, retarding the touchdown.

At that moment, realizing the tendency of delay in the touch, the commander reported to have acted in the commands, aiming to make the landing in a commanded manner.

Both pilots reported that, during the braking, the runway was slippery.

According to the pilots, they did not realize clearly that the aircraft had stopped at the stopway, beyond the limits of the runway.

However, they observed proximity to some light bulbs on the runway and so reported the fact to TWR-FI, believing it was possible that they had broken one of them.

The flight attendants reported not having noticed any changes or abnormalities during the landing.

1.14 Fire.

There was no fire.

1.15 Survival aspects.

Nil.

1.16 Tests and research.

Nil.

1.17 Organizational and management information.

About the operation in adverse weather conditions, the copilot reported that, culturally, the operator instructed the commander to assume the position of Pilot Flying, especially in heavy rain scenarios.

On the flight that originated the incident, the commander reported that he did not consider it necessary to take over the commands, because, according to his perception, he believed it was a light rain.

1.18 Operational information.

The aircraft took off from SBCT to SBFI to conduct a regular passenger flight segment. It was the third leg of the day and the operation of the aircraft was in charge of the copilot (Pilot Flying) on that flight.

The take-off took place at 0137 (UTC), so the entire flight was conducted at night. The phases of takeoff, climb and cruise were performed without any abnormality. Detours were en route to avoid weather formations. The crew was prepared to perform the RNAV procedure of runway 32, on 12OCT2017, according to the guidelines of the air traffic control bodies. An approach and landing procedure briefing was held, including the possibility of a go-around procedure.

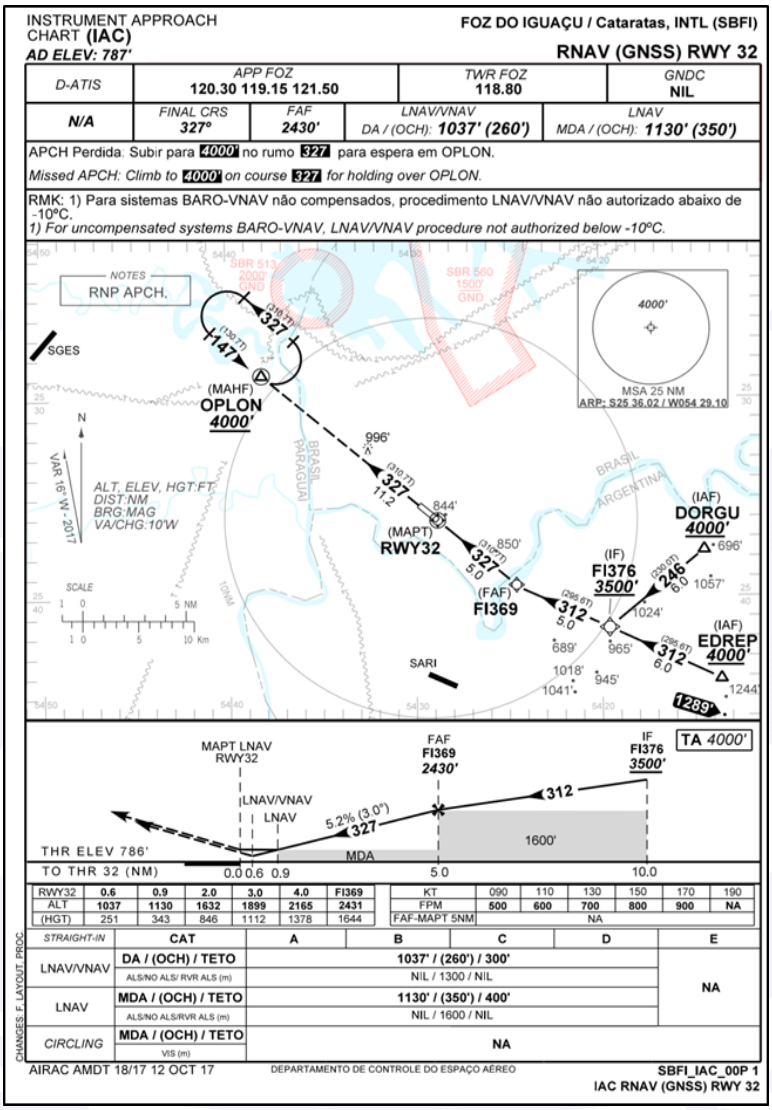


Figure 7 - Instrument approximation chart (RNAV of runway 32) for SBFI, valid on 18NOV2017.

According to the Airplane Flight Manual (AFM) Rev. 40, of 29JUN2017, produced by the manufacturer, the maximum value of tail wind component allowed for takeoffs and landings on the Boeing 737-800 was of 10kt.

The Flight Standards Manual (FSM) Rev. 20, from APR2017, produced by the operator and in force at the time of the incident, recommended in Chapter 5 - General Procedures, Section 5.9 - Operational Limits -Tailwind Limits that:

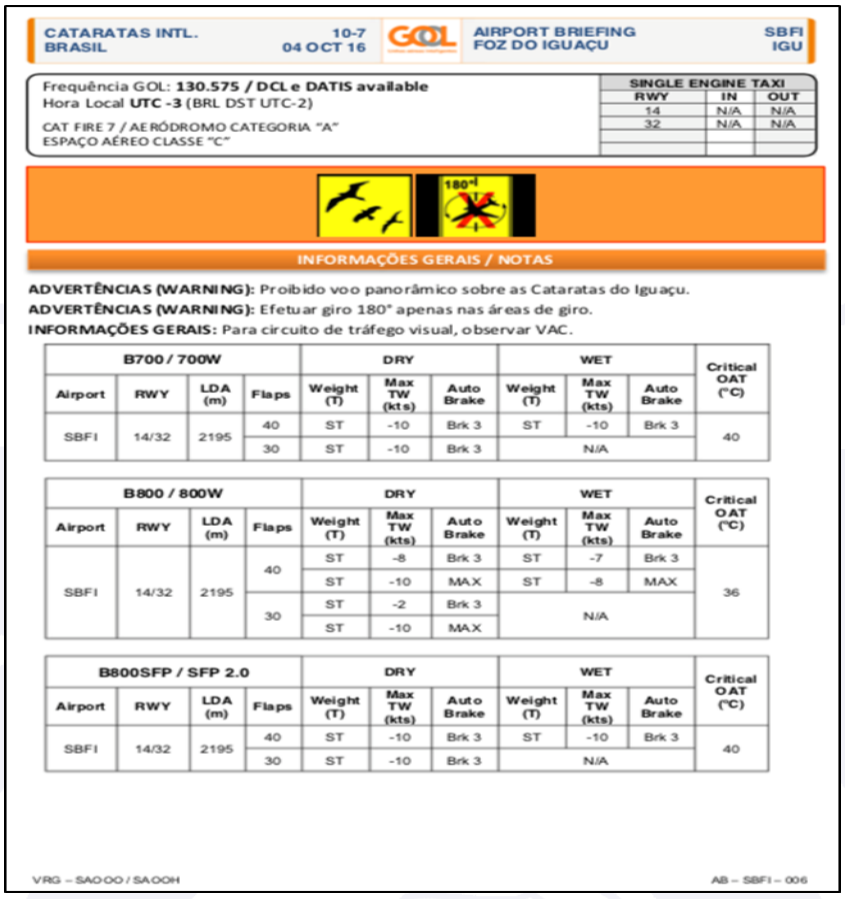
> The tail wind component limit must be checked at Airport Briefing, or if applicable, Flight Status for the location.

The operator provided a local Airport Briefing for the crews. This documentation was intended to provide general information and to standardize operating parameters in a given location.

The SBFI Airport Briefing, issued by the operator at the time of the incident, limited landing operations with tail wind component up to 10kt, for wet runway conditions.

The Flight Crew Operations Manual (FCOM) specified that pilots should consult the Flight Management Computer (FMC), in order to obtain wind direction and intensity information.

At the time of the occurrence, the SBFI Airport Briefing did not restrict the copilot operation in wet runway conditions.



CATARATAS INTL. BRASIL 10-7 04 OCT 16 — AIRPORT BRIEFING FOZ DO IGUAÇU SBFI IGU

Frequência GOL: **130.575 / DCL e DATIS available**
Hora Local **UTC -3** (BRL DST UTC-2)
CAT FIRE 7 / AERÓDROMO CATEGORIA "A"
ESPAÇO AÉREO CLASSE "C"

SINGLE ENGINE TAXI		
RWY	IN	OUT
14	N/A	N/A
32	N/A	N/A

INFORMAÇÕES GERAIS / NOTAS

ADVERTÊNCIAS (WARNING): Proibido voo panorâmico sobre as Cataratas do Iguaçu.
ADVERTÊNCIAS (WARNING): Efetuar giro 180° apenas nas áreas de giro.
INFORMAÇÕES GERAIS: Para circuito de tráfego visual, observar VAC.

B700 / 700W				DRY			WET			Critical OAT (°C)
Airport	RWY	LDA (m)	Flaps	Weight (T)	Max TW (kts)	Auto Brake	Weight (T)	Max TW (kts)	Auto Brake	
SBFI	14/32	2195	40	ST	-10	Brk 3	ST	-10	Brk 3	40
			30	ST	-10	Brk 3	N/A			

B800 / 800W				DRY			WET			Critical OAT (°C)
Airport	RWY	LDA (m)	Flaps	Weight (T)	Max TW (kts)	Auto Brake	Weight (T)	Max TW (kts)	Auto Brake	
SBFI	14/32	2195	40	ST	-8	Brk 3	ST	-7	Brk 3	36
				ST	-10	MAX	ST	-8	MAX	
			30	ST	-2	Brk 3	N/A			
				ST	-10	MAX				

B800SFP / SFP 2.0				DRY			WET			Critical OAT (°C)
Airport	RWY	LDA (m)	Flaps	Weight (T)	Max TW (kts)	Auto Brake	Weight (T)	Max TW (kts)	Auto Brake	
SBFI	14/32	2195	40	ST	-10	Brk 3	ST	-10	Brk 3	40
			30	ST	-10	Brk 3	N/A			

VRG – SAOOO / SAOOH AB – SBFI – 006

Figure 8 - SBFI Aerodrome Airport Briefing.

While performing the descent, before starting the RNAV procedure for runway 32, the PR-GXW requested the Foz do Iguaçu Approach Control (APP-FI) wind information. The APP-FI reported wind with direction of 200° and intensity of 6kt.

During the approach, another aircraft that was descending to SBFI, behind the PR-GXW, contacted the APP-FI requesting meteorological information of the locality. This communication was recorded by the CVR of PR-GXW.

During the communication, APP-FI reported, among other things, that the runway in use was the 32; that the surface wind was coming from 160° with 9kt of intensity; that the procedure in use was the RNAV of runway 32; and that the Aerodrome operated at the meteorological minima for approach.

The aircraft questioned why the runway in use was the 32, since the wind favored operations for runway 14.

APP-FI replied that severe turbulence had been reported in runway 14 approach area and that two aircraft had previously went around during attempted landing on runway 14. It further reported that two aircraft had landed successfully on runway 32.

During this communication, the PR-GXW was on the final approach, preparing to land. Soon after communicating with the other aircraft, the APP-FI instructed the PR-GXW to call the TWR-FI.

When establishing contact with the TWR-FI, the PR-GXW pilots were instructed to continue the approach and inform when visual with the runway. TWR-FI also reported that the runway was wet.

The crew spotted the runway just above the Decision Altitude (DA) envisaged in the RNAV procedure. Before the pilots reported being visual with the runway, TWR-FI spotted

the aircraft and cleared the landing, but did not report the direction and intensity of the wind.

There was no questioning by the pilots to TWR-FI about the surface wind in SBFI.

The Manual of the Aeronautical Command (MCA) 100-16 / 2016 that provides on "Air Traffic Phraseology" had in Chapter 3 Standardized Phraseologies, Section 3.4 Aerodrome Control Service, item 3.4.3.3.2 the information to be provided to the aircraft at the time of the final approach and landing authorization.

According to the MCA, the control tower should pass the following information to the aircraft that reported being in the final approach for landing:

a) call sign of the aircraft;

b) authorization;

c) direction and speed of the wind; and

d) supplementary instructions (if any).

During the approach and landing procedure, the crewmembers had access to two wind data from the APP-FI: one provided to the PR-GXW (200° / 6kt); and one rendered to another aircraft following them for landing on SBFI (160° / 9kt).

The Boeing 737-800 aircraft's systems were capable of providing pilots with wind intensity and direction information. However, during the final approach, the CVR did not record dialogues among the crew about the direction and / or intensity of the wind.

In an interview, the crew reported that they considered as reference the wind information provided by the APP-FI and decided to proceed with the approach for landing on runway 32.

On landing and approach speeds, the manufacturer produced the Flight Crew Training Manual (FCTM) Rev. 16 of 30JUN2017, which recommended that the speed to be maintained during approach should be between Vref + 5kt and Vref + 20kt. The performance calculations related to the landing of the PR-GXW in SBFI on the night of the incident indicated a Vref equal to 127kt.

Regarding the descent rate during the approach and landing phases, the FCTM stated that the value of the descent rate to be employed should be between 700ft / min and 900ft / min, depending on the weight of the aircraft.

About the flare (the moment before the touch of the plane on the runway), the manual emphasized that the maneuver should not be prolonged in an attempt of a perfectly smooth landing.

> Do not prolong the flare in an attempt to achieve a perfectly smooth touchdown. A smooth touchdown is not the criterion for a safe landing.

The FCTM also described that under normal conditions the flare would last between 4 and 8 seconds and should be performed in such a way that the touch of the aircraft on the runway occurred between 300m and 600m after the threshold.

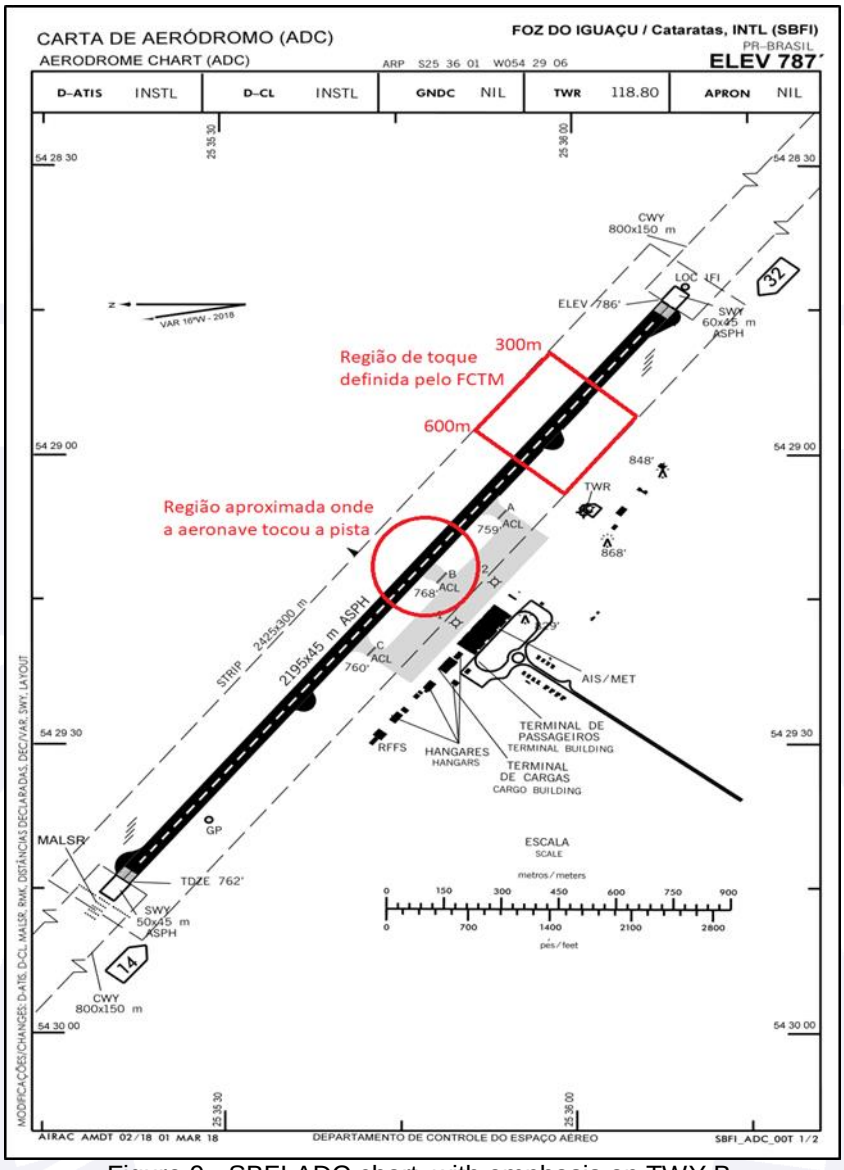


Figure 9 - SBFI ADC chart, with emphasis on TWY B.

As for the actuation of the reversers, the operation manuals recommended that pilots start to move the throttle out of the reverse range when the aircraft reaches an indicated speed around 60kt.

The data recorder registered that the crew uncoupled the autopilot when the aircraft was 200ft high relative to the runway. The crossing of the threshold occurred with 50ft of height, rate of descent of approximately 500ft / min and indicated speed of 138kt (Vref + 11kt).

According to reports from the crew, an extended flare was performed, seeking a lower rate of descent, in order to prevent a hard landing.

Despite having crossed the threshold with Vref + 11kt (138kt), speed above the recommended by the FCTM (Vref + 5kt) for approach, the crew did not exceed the manual set limit (Vref + 20kt) for stabilized approaches.

According to data extracted from FDR, the tailwind component remained above 10kt during the final approach. After crossing the runway threshold, the tail wind component increased, reaching as high as 16kt shortly before touching the ground.

The touch of the aircraft on the runway occurred near taxiway "B", approximately 1.000m ahead of runway 32's threshold.

The copilot reported that this was the first time that he performed, in the Pilot Flying function, a landing in rain and wet conditions, such as presented in SBFI.

He also reported that in some locations, Flight Status or Airport Briefing restricted the operation to the commander when there was rain or wet conditions. He also reported that he had sometimes thought of carrying out a go-around procedure, but that the commander's posture had given him confidence in the operation.

The commander reported that the approach was being developed normally and that they made visual contact with the runway when they reached Decision Altitude (DA). He also reported that he had noticed a relative delay in the "flare" of the aircraft and intervened at the controls, keeping the control wheel ahead, in order to "command" the landing. After touching the runway, he reported that he had the perception that the aircraft was slipping.

The FDR data showed that the speed brakes acted simultaneously to the touch of the aircraft on the runway. The reversers were opened two seconds after the touch and the engines developed maximum traction six seconds after the aircraft touched the runway. The hydraulic pressure in the brake assembly gradually increased, reaching 3.000psi five seconds after the touch, remaining close to that value until the aircraft stopped altogether.

During the deceleration, the aircraft reached 65kt of indicated speed when it was 400m from the end of the runway. At this point, the crew began to stop using the reversers, as recommended by the FCTM, and gradually moved the throttles to the idle position, which lasted seventeen seconds.

The aircraft decelerated and stopped at the stopway, behind the opposite threshold (14) and beyond the limit of the runway in use for landing (32).

At the time of the landing, the weight of the aircraft was of 56.349kg. Performance calculations for SBFI landing, with wet runway, indicated that the maximum operating weight under these conditions was 70.728kg.

After the incident, the operator updated the Flight Status of the SBFI locality, restricting the operation to the commander of the aircraft in wet conditions.

1.19 Additional information.

Nil.

1.20 Useful or effective investigation techniques.

Nil.

2. ANALYSIS.

The PR-GXW aircraft was manufactured in 2014, it was registered in the category of Regular Public Air Transport (TPR), had a total of 11.700 hours and 57 minutes of flight and had valid Airworthiness Certificate (CA).

The maintenance records were updated. The last inspection of the aircraft, the "Check A" type, was carried out on 14NOV2017, having flown 42 hours and 52 minutes after the inspection.

All aircraft systems and equipment worked as expected.

All the crewmembers were qualified and had experience in the aircraft and in the type of operation.

When preparing for the flight, the meteorological information available to the crew, regarding the SBFI region, indicated rainfall instability for the expected landing time at the destination.

The latest measurements of friction and macro texture at the SBFI Aerodrome did not indicate problems on the runway, nor did they propose corrective actions.

The aircraft took off from SBCT to SBFI at 0137 (UTC), to carry out the third leg of the day. The operation of the aircraft was in charge of the copilot on that flight. There was no SBFI Airport Briefing restriction on the copilot's operation at that location.

The phases of takeoff, climb and cruise were performed without any abnormality. Deviations were made on the route because of meteorology. The entire flight was conducted at night.

There were reports of turbulence and heavy weather formations in the runway 14 approach sector. For this reason, the PR-GXW was directed to landing towards runway 32, despite wind favoring operations for runway 14.

The RNAV procedure of runway 32, from 12OCT2017, was performed by the crew according to the orientations contained in the approach chart.

The FSM advocated that the intensity limit of the tailwind component should be checked at the local Airport Briefing. The SBFI Airport Briefing pointed out that for the wet runway the tail wind limit at the Aerodrome was 10kt. The maximum value for tail wind landing predicted in the FSM for the Boeing 737-800 was 10kt.

Thus, it was concluded that the operator considered that the SBFI tailwind operation could occur at the aircraft limit, with no additional restrictions related to the Aerodrome characteristics or the wet runway condition.

During the descent, PR-GXW pilots requested wind information from the APP-FI, which reported wind coming from the 200° direction and with intensity of 6kt.

Under these conditions, the tailwind component for operation on runway 32 would be 3kt, therefore, below the limit specified in the manuals and at Airport Briefing.

When the PR-GXW was initiating the final approach, still in contact with APP-FI, another aircraft requested weather information from the control body. The APP-FI informed this aircraft that the wind at that time was coming from the 160° direction with intensity of 9kt.

Under these conditions, the tailwind component for operation on runway 32 would be 8kt, therefore, below the limit specified in the manuals and at Airport Briefing.

Upon seeing the aircraft, TWR-FI authorized the landing, but did not inform the direction and intensity of the wind to the pilots, as foreseen in MCA 100-16 / 2016.

Therefore, the pilots had available only the information previously provided by the APP-FI, or those provided directly by aircraft systems to decide on landing or performing a go-around procedure.

The Boeing 737-800 had on-board equipment that allowed pilots to check the direction and intensity of the wind. However, the CVR of the aircraft did not record dialogues between the crew on direction and intensity of the wind, during the final approach.

In an interview, the pilots reported that they used the information provided by the air traffic control body (APP-FI) as a parameter to carry out the landing.

In the course of the landing approach, the aircraft systems continued to record the direction and intensity of the wind, and hence the tailwind component. The tail wind values remained above 10kt, reaching 16kt shortly before touching the runway.

That demonstrated a significant difference between the values provided by the aircraft systems and the values provided by the APP-FI, and suggested, in the face of the meteorological adversities encountered, the possibility of a greater focus of the pilots on the conduct of the landing maneuver, in detriment of the aircraft's internal parameters related to the direction and intensity of the wind.

The copilot's report that this was his first landing as a Pilot Flying, in rainy wet weather, denoted his little experience of that kind of operation.

The presentation of higher levels of anxiety and expectation, given the personal motivation for the landing and the relative insecurity reported by the copilot, referring to his difficulty in visualizing the runway, may have caused difficulties in maintaining his attention.

Through the CVR audio, it was possible to notice that, although the command of the aircraft was with the copilot, the commander kept control over the whole operation, instructing the execution of the movements and actions of the copilot to carry out the landing.

The context above indicated, therefore, a relatively compromised situational awareness in the cabin.

Despite the crew's control over the aircraft, their decisions were based on outdated APP-FI information, given the lack of up-to-date information on the direction and intensity of the wind at the time of the PR-GXW landing and the contrast with the information provided by the aircraft's on-board equipment, which allowed pilots to verify such parameters.

The approach and landing techniques defined in the manufacturers and operator's manuals recommended that the crew maintain a speed equal to Vref + 5kt during threshold intersection.

The manuals defined as the recommended descent rate for the landing values between 700ft / min and 900ft / min, depending on the weight of the aircraft, and maximum component of tail wind of 10kt.

In addition, the manuals emphasized that the flare should not be prolonged in the attempt of a soft landing.

The following aspects were highlighted in the events related to the approach to landing in SBFI:

a) the operation of the aircraft was being conducted by the copilot;

b) the APP-FI provided wind information representing tail wind components below 10kt. However, the aircraft was subjected to tail wind component with an intensity of more than 10kt, still with 200ft, reaching 16kt shortly before touching the runway;

c) it was raining at the time of the approach in SBFI and the runway was wet;

d) runway 32 of SBFI had an altitude difference of 54ft between the thresholds and, therefore, a negative slope equal to 0.75%, that is declivity;

e) the crew had a descent rate of approximately 500ft / min, lower than recommended in manual (700ft / min at 900ft / min), in order to prevent a hard landing. The rate of descent of 500ft / min delayed the beginning of the flare;

f) the aircraft's speed at the time of the threshold crossing was 138kt (Vref + 11kt), 6kt higher than the recommended speed (Vref + 5 = 132kt) for the day of the incident;

g) speed of 138kt, added to the tail wind of 16kt, resulted in a ground speed of 154kt; and

h) the flare was prolonged by the pilots, in order to soften the touch on the runway, technique that the manuals considered as not recommended.

All of these factors contributed to the touch down of the aircraft occurring approximately 1.000m ahead of runway 32's threshold at a point near taxiway B (Figure 9).

Possibly, the insecurity reported by the copilot because of his difficulty in visualizing the runway was a reinforcing factor for prolonged flare.

In view of the difficulty encountered, it was plausible to suppose that the copilot passed the commands of the flight to the commander or carried out a go-around procedure, mainly because it was the first time that he would make a night landing in those operational and meteorological conditions.

However, his motivation for completing the landing was high, and it was a personal challenge to be transposed in face of the trust he was given by the commander. Nevertheless, it was not possible to disregard the fact that this high motivation led the copilot to perform a procedure under a high degree of anxiety and expectation, which impaired his situational awareness in relation to his effective ability to perform the landing under those conditions.

The aircraft's tires were in good condition, with deep grooves, no sharp wear, no apparent plies and no hydroplaning marks. The wear check parameters of the main landing gear brake assemblies indicated that the aircraft brakes had normal operating conditions.

After landing, the aircraft's braking systems acted as expected. The speed brakes were activated simultaneously, as the main landing gear touched the runway. The hydraulic pressure in the brake assembly reached 3.000psi five seconds after the touch, remaining close to that value until the total stop of the aircraft. The 3.000psi value was compatible with normal braking system operation.

The pilots turned on the reversers that opened normally two seconds after the touch. Four seconds later (six seconds after landing), the engines began to develop maximum traction (maximum reversers). However, when the aircraft reached 65kt of indicated speed, the pilots began to close the reversers.

In normal landing conditions, the operation manuals recommended the closing of the reversers when the aircraft reached an indicated speed around 60kt. Therefore, the action of the pilots was consistent with what was expected for normal landings. However, under the conditions presented, this action may have influenced landing distance.

Therefore, it was concluded that the crew based their approach and landing procedure on parameters of direction and wind intensity that did not match the reality presented in SBFI, thus impairing their level of situational awareness and the perception of the associated operational consequences to the decision of completing the landing under those conditions.

This scenario compromised the development of approach, flare, landing and deceleration of the aircraft, which culminated in the excursion of the runway by the opposite end.

3. CONCLUSIONS.

3.1 Facts.

a) the pilots had valid Aeronautical Medical Certificate (CMA);

b) the pilots had valid type and IFRA Ratings;

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

d) the aircraft had valid Airworthiness Certificate (CA);

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

f) the airframe and engines logbooks recordings were updated;

g) the weather conditions were favorable for the flight;

h) it was raining at the time of the landing and the runway was wet;

i) the prevailing wind at the Aerodrome was favorable for landing and take-off operation towards runway 14;

j) there were reports of heavy meteorological formations and severe turbulence in the runway approach sector 14;

k) the air traffic control was directing operations to runway 32, despite the tail wind;

l) the APP-FI reported to PR-GXW wind of 200° with 6kt;

m) the APP-FI reported a wind of 160° with 9kt for the aircraft behind the PR-GXW;

n) the tail wind component limit for landings and take-offs on the Boeing 737-800 was of 10kt;

o) the crew used the wind information provided by APP-FI as a reference;

p) the crew decided to proceed to the landing;

q) TWR-FI did not report wind direction and intensity at the time it authorized the aircraft to land;

r) the approach was performed with lower descent rate than the one recommended in manual;

s) the threshold crossing was performed with speed above the one recommended in manual, but within the limits for stabilized approach;

t) the flare was prolonged;

u) the aircraft landed with tailwind of 16kt, a value above the manual limit for the B737-800 (10kt);

v) the touch on the runway occurred at a point of 1000m ahead of threshold 32;

w) the aircraft braking systems acted as expected;

x) the pilots applied the reversers after the touch and the system worked correctly;

y) the crew started to close the reversers with a speed of 65 kt;

z) the pilots reproduced cognitive and psychomotor reactions typical of a normal landing scene, on a dry runway and with a head wind;

aa) the tires were in good conditions;

bb) the brake assemblies had the wear check parameter above the maintenance limit;

cc) the last measurements of friction and macro texture performed in SBFI did not find problems nor did they indicate corrective actions to be performed;

dd) the aircraft has exceeded the limit of runway 32, stopping at the stopway after runway 14 threshold;

ee) the aircraft was not damaged; and

ff) all occupants left unharmed.

3.2 Contributing factors.

- **Control skills – a contributor.**

The maintenance of a lower descent rate than the one recommended in manual and the prolongation of the flare contributed to the touch on the runway occurring at a point approximately 1.000m ahead of threshold 32.

- **Attention – undetermined.**

In view of the meteorological adversities encountered, it is possible that pilots have established a greater focus on the landing maneuver, to the detriment of control of the aircraft's internal parameters, which would have provided a more precise information about the existing wind component for the landing.

- **Emotional state – undetermined.**

The meteorological scenario, the poor copilot's experience in landing with rain and wet runway, and the high personal motivation to complete the maneuver, may have contributed to an increase in the copilot’s anxiety levels, hampering his operational performance in the landing.

- **Use of phraseology by ATS – undetermined.**

The absence of TWR-FI direction and wind speed information may have contributed to a lowering of the situational awareness level of the pilots in relation to operational conditions at the time of the landing.

- **Piloting judgment – a contributor.**

The decision to continue the approach without updated information on wind direction and intensity was an inadequate assessment of the operational context by the pilots, since they had the means (TWR-FI and aircraft systems) to accurately identify these parameters in a timely manner.

- **Motivation – undetermined.**

The high motivation of the copilot to complete the landing, may have favored a more anxious emotional state, hindering the maintenance of adequate levels of attention and situational awareness during the approach and the landing phase.

- **Perception – a contributor.**

The approach and the landing phase in SBFI were based on parameters of direction and intensity of wind that did not match the actual conditions presented, a fact that hampered the maintenance of an adequate situational awareness by the pilots, and the precise perception of the resulting operational consequences.

- **Decision-making process – a contributor.**

The SBFI landing based on outdated direction and wind intensity parameters associated with the operation by a copilot who was not accustomed to landing in rainy conditions, indicated weaknesses in the process of analysis, judgment and decision making on the existent operating conditions. These weaknesses compromised the

development of approach, flare, landing and deceleration of the aircraft, culminating in the excursion of the runway by its opposite end.

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):

IG-146/CENIPA/2017 - 01 Issued on 04/08/2019

Work with GOL Airlines S.A, so that the training of that operator's pilots emphasize the landing techniques described in the aircraft operation manuals, especially with respect to the adequate descent rate in the final approach and the parameters for the execution of the flare during the landing, especially in wet conditions.

IG-146/CENIPA/2017 - 02 Issued on 04/08/2019

Act together with GOL Airlines S.A, so that the training of that operator's pilots emphasize the techniques of go-around procedures and the factors that lead to the execution of this procedure, especially when there is a component of tail wind that can cause unacceptable risks to a safe operation.

To the Air Space Control Department (DECEA):

IG-146/CENIPA/2017 - 03 Issued on 04/08/2019

Work with the TWR-FI flight controllers, in order to reinforce to those professionals the need to faithfully comply with MCA 100-16 / 2016, especially with respect to the information to be transmitted to the crews in the final approach for landing, such as direction and intensity of the wind at the Aerodrome.

5. CORRECTIVE OR PREVENTATIVE ACTION ALREADY TAKEN.

The operator reviewed the SBFI Flight Status and made the operation on wet runway to be exclusive the commander's.

On April 08th, 2019.