COMANDO DA AERONÁUTICA

CENTRO DE INVESTIGAÇÃO E PREVENÇÃO DE ACIDENTES AERONÁUTICOS

FINAL REPORT
IG - 177/CENIPA/2018

OCCURRENCE:	**SERIOUS INCIDENT**
AIRCRAFT:	**YV2937**
MODEL:	**B737-2Y5**
DATE:	**28NOV2018**

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 28NOV2018 serious incident with the B737-2Y5 aircraft model, registration YV2937. The accident was classified as “[RE] Runway Excursion”.

During the landing on runway 29 of Eduardo Gomes Aerodrome (SBEG), Manaus - AM, the aircraft crossed the runway limits, coming to a full stop 100 meters after threshold 11, in soft terrain.

The aircraft had minor damage.

All the occupants left unharmed.

An Accredited Representative of the *Junta Investigadora de Accidentes de Aviación* (JIAA) - Venezuela (State where the operator was registered) was designated for participation in the investigation.

CONTENTS

GLOSSARY OF TECHNICAL TERMS AND ABBREVIATIONS

ALS	Approach Light System
AMM	Aircraft Maintenance Manual
ANAC	Brazil's National Civil Aviation Agency
APP-MN	Approach Control - Manaus
ATCO	Air Traffic Controller
ATS	Air Traffic Services
CA	Airworthiness Certificate
CCTV	Closed-Circuit Television
CENIPA	Aeronautical Accident Investigation and Prevention Center
CG	Center of Gravity
CMA	Aeronautical Medical Certificate
COA	Airport Operations Center
COE	Emergency Operator Center
CVR	Cockpit Voice Recorder
DECEA	Air Space Control Department
DIAF	*Direccion de la Industria Aeronautica Del Ecuador*
DTCEA-EG	Air Space Control Detachment – Eduardo Gomes
EMS-EG	Surface Weather Station - Eduardo Gomes
FCOM	Flight Crew Operations Manual
FDR	Flight Data Recorder
FOD	Foreign Object Damage
ICA	Command of Aeronautics' Instruction
ICAO	International Civil Aviation Organization
IFR	Instrument Flight Rules
IFRA	Instrument Flight Rating - Airplane
IMC	Instrument Meteorological Conditions
JIAA	*Junta Investigadora de Accidentes de Aviación*
LDA	Landing Distance Available
MCA	Aeronautics Command Manual
METAR	Aviation Routine Weather Report
MOPS	Operations Manual
MPCINC	Fire Section Operating Procedures Manual
NOTAM	Notice to Airmen
PCINC	Firefighting Plan
PI	Performance Inflight
PLA	Airline Pilot License - Airplane
PLEM	Aeronautical Emergency Plan

PN	Part Number
PPR	Private Pilot License – Airplane
QAP	Code language, corresponding to “keep listening”
QDR	Magnetic Marking
QRH	Quick Reference Handbook
RBAC	Brazilian Civil Aviation Regulation
REIL	Runway End Identifier Lights
SBEG	ICAO Location Designator - Eduardo Gomes Aerodrome, Manaus - AM
SERIPA VII	Seventh Regional Aeronautical Accident Investigation and Prevention Service
SN	Serial Number
SPECI	Selected Special Aeronautical Weather Report
SVMI	ICAO Location Designator - Maiquetia Aerodrome - Simon Bolivar - Venezuela
TAF	Terminal Aerodrome Forecast
TBO	Time Between Overhaul
TDZE	Touch Down Zone
TLV	Life Time Limit
TPR	Aircraft Registration Category of Private Service
TWR-EG	Eduardo Gomes Control Tower - AM
UTC	Universal Time Coordinated
VFR	Visual Flight Rules
VMC	Visual Meteorological Conditions
VRef	Reference Landing Speed

1. FACTUAL INFORMATION.

Aircraft	**Model:** B737-2Y5 **Registration:** YV2937 **Manufacturer:** Boeing	**Operator:** Avior Airlines C.A.
Occurrence	**Date/time:** 28NOV2018 - 1943 UTC **Location:** Eduardo Gomes Aerodrome (SBEG) **Lat.** 03°02'18"S **Long.** 060°03'45"W **Municipality – State:** Manaus – AM	**Type(s):** "[RE] Runway Excursion" **Subtype(s):** NIL

1.1 History of the flight.

The aircraft took off from the Maiquetia Aerodrome - Simón Bolívar (SVMI) - Venezuela, to the Eduardo Gomes Aerodrome (SBEG), Manaus - AM, at about 1715 (UTC), in order to transport personnel, with 5 crewmembers and 39 passengers on board.

After landing on SBEG runway 29, the aircraft passed the Landing Distance Available (LDA), leaving the runway from its opposite end (overrun), coming to a stop on unpaved land.

The aircraft had minor damage.

All occupants left unharmed.

1.2 Injuries to persons.

Injuries	Crew	Passengers	Others
Fatal	-	-	-
Serious	-	-	-
Minor	-	-	-
None	5	39	-

1.3 Damage to the aircraft.

The only damage observed was the point where the leakage of the hydraulic fluid occurred in the body of the System A pressure transmitter, which occurred in flight.

No tire damage was observed that could characterize aquaplaning.

1.4 Other damage.

There was damage to the end of runway markings, at threshold 11 of SBEG.

1.5 Personnel information.

1.5.1 Crew's flight experience.

Flight Hours		
	Pilot	Copilot
Total	4.850:00	10.100:00
Total in the last 30 days	37:20	59:25
Total in the last 24 hours	06:00	04:45
In this type of aircraft	2.000:00	4.000:00
In this type in the last 30 days	20:00	13:25
In this type in the last 24 hours	05:00	02:30

N.B.: The data related to the flown hours were obtained through records provided by the operator and the crewmembers.

1.5.2 Personnel training.

The pilot took the PPR course at the *Centro de Instrucción Aeronáutica* AVIOR, in Barcelona, Venezuela, in 2010.

The copilot took the PPR course at the AVENSA, in Caracas, in 1981.

1.5.3 Category of licenses and validity of certificates.

The pilot had the PLA License and had valid B732 aircraft type Rating (which included the B737-2Y5 model) and IFRA Rating, as well as Language Proficiency Certification – ICAO 6.

The copilot had the PLA License and had valid B732, B734 aircraft type Rating and IFRA Rating, as well as Language Proficiency Certification – ICAO 4.

1.5.4 Qualification and flight experience.

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

The commander started his training at Avior Airlines C.A. in 2008. In 2010, he was qualified as a private pilot and, in 2011, he was qualified as a commercial pilot. He worked as a copilot for four years and six months. Since February 2017, he was working as commander.

The copilot was trained 21 years ago and has flown most of his operational life in turboprop aircraft. Four years ago, he had started operating on reaction aircraft (Boeing 737-200 and 737-400), working as a copilot.

1.5.5 Validity of medical certificate.

The pilots had valid CMAs.

1.6 Aircraft information.

The aircraft, serial number 23847, was manufactured by Boeing, in 1987, and it was registered in the TPR category.

The aircraft had valid Airworthiness Certificate (CA).

The technical maintenance records were updated.

The last inspection of the aircraft, the “Check A+2A+3A+B” type was carried out on 21NOV2018 by the maintenance organization Avior Airlines C.A, in Venezuela, with the aircraft having flown 27 hours and 45 minutes after the inspection.

The last inspection of the aircraft, the “Check C” type was carried out on 23SEPT2018 by the maintenance organization *Dirección de la Industria Aeronáutica Del Ecuador* (DIAF), in Ecuador, with the aircraft having flown 2.293 hours and 20 minutes after the inspection.

According to the maintenance report sheet ROI-DB-011, from 27NOV2018, there was the following discrepancy:

> “When Flap 5 was selected, there was a drop in the hydraulic pressure of System A, with the Low-Pressure light coming on, right after the light went out, but the controls were hard.”

For this occasion, the corrective action taken by the maintenance team was to perform an operational test, as provided for in the Aircraft Maintenance Manual (AMM) 27-51-00, which obtained a satisfactory result.

The maintenance report sheet ROI-DB-11, on the day of the occurrence, contained the following discrepancy:

> "When putting Flap 5, we lost System A, and we proceeded according to the QRH. For landing, the Flap only extended to position 10. The runway was wet with rain and the braking was not very effective and the #1 reverser did not open. We had a runway excursion."

After the aircraft was removed to the apron, a maintenance work was carried out on System A.

The main hydraulic reservoir was refilled and pressurized, when it was observed that the hydraulic leak occurred through the body of the System A Hydraulic Pressure Transmitter, Part Number (PN) ST-107R and Serial Number (SN) 7929A.

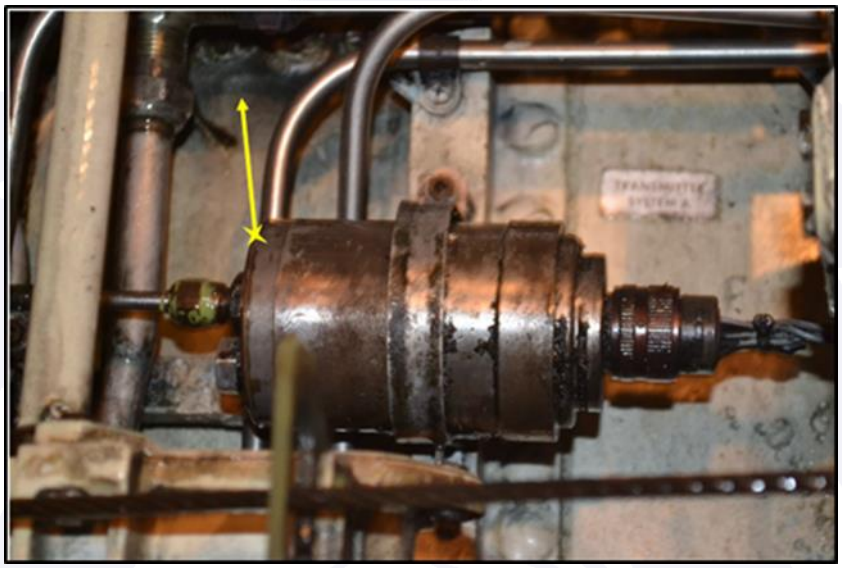


Figure 1 - System A pressure transmitter (PN ST-107R). The yellow arrow indicates the location and direction that the hydraulic fluid leak was observed.

1.7 Meteorological information.

The SBEG's Terminal Aerodrome Forecast (TAF) reported 30% probability of thunderstorms with scattered clouds at 2,000 feet and few clouds at 2,500 feet of Cumulonimbus type, between 1900 and 2100 (UTC), according to the message below:

> TAF SBEG 281600Z 2818/2918 11008KT 9999 BKN020 FEW025TCU TN24/2907Z TX34/2918Z PROB30 2819/2821 TS SCT020 FEW025CB BECMG 2822/2824 12005KT FEW015 BECMG 2905/2906 09005KT BKN006 BECMG 2912/2914 05005KT SCT015 BECMG 2916/2918 SCT020 FEW025TCU RMK PEN=

The METAR and the SPECI, between 1900 and 2000 (UTC), showed the following information:

> SBEG 281900Z 29003KT 9999 VCSH SCT012 SCT020 FEW025TCU 31/23 Q1008=
>
> SPECI SBEG 281920Z 23003KT 9999 TS VCSH SCT012 SCT018 FEW023CB 30/24 Q1008=
>
> SBEG 282000Z 10014KT 1000 +TSRA BKN008 FEW020CB SCT025 25/23 Q1008=
>
> SPECI SBEG 282010Z 12010KT 9999 -TSRA SCT012 SCT018 FEW020CB 25/23 Q1008=

It was found that, during the entire approach of the YV2937 to landing, due to the prevailing wind, runway 29 was being operated. However, when calling the TWR-EG for landing, it informed that the wind was 180 degrees with 16kt, a favorable condition for landing on runway 11.

During the landing, therefore, there was a cross wind, which at that time produced a tail component of approximately 5kt.

The copilot questioned the conditions of the Aerodrome and he was informed that the Aerodrome was operating under VMC, with light rain on the approach and through the tower.

Also, according to the crew information, during the final short landing, the rain that fell on the runway did not allow the opposite threshold to be visible.

Figure 2 - Image of the CCTV of taxiway “A” and runway 11 at the time of the YV2937 landing - recording with Manaus local date and time (UTC-4).

It is noteworthy that the Infraero did not have a rain gauge, therefore, it did not have access to the measurement of the rain that fell on the Aerodrome, having to use the information provided by the EMS-EG.

1.8 Aids to navigation.

Runway 29 was the one used for landing and the procedure in use was the VOR Y - RWY 29.

According to the NOTAM information, all navigation and landing aids operated normally when the aircraft approached.

1.9 Communications.

According to the communication transcript between the YV2937 and the control agencies, it was found that the crewmembers kept radiotelephony contact with the APP-MN and with the TWR-EG, so that there was no technical communication equipment abnormality during the flight.

In order to support the analysis of the sequence of events that preceded the landing, the Investigation Team highlighted some transmissions that could assist in understanding the dynamics of the incident. To record the times described in this item, the Coordinated Universal Time (UTC) was used as a reference.

- 19h18min12s: the YV2937 made the initial call to the APP-MN;

- 19h18min17s: the APP-MN received the traffic and authorized the descent up to 4,000ft, VIA SEMLA 1B arrival, with altimeter adjustment 1008;

- 19h18min32s: the APP-MN questioned if the YV2937 could fly directly to the DAGTI position;

- 19h18min45s: the YV2937 confirmed flying straight to DAGTI and questioned if the runway in use was 29;

- 19h19min03s: the APP-MN informed that the procedure in use was the VOR Y for runway 29;

- 19h25min33s: the APP-MN reported that the wind for runway 29 was 170 degrees with 8kt;

> "for your information the runway is two niner, wind one seven zero degrees, eight knots"

- 19h26min38s: the YV2937 confirmed receiving the information;

- 19h32min46s: the YV2937 informed the APP-MN that it was having problems with the hydraulic system and requested to perform a "360" in the current position;

- 19h33min09s: the APP-MN authorized the YV2937 to keep the present position at 4,000ft;

- 19h37min50s: the YV2937 informed the APP-MN that it was ready for the approach;

- 19h38min02s: the APP-MN authorized the YV2937 to complete the approach and contact the TWR-EG at frequency 118.30;

- 19h38min14s: the YV2937 called the TWR-EG and informed that it was ready for the approach;

- 19h38min21s: the TWR-EG authorized the landing of the YV2937 on runway 29 and reported wind of 180 degrees, with 14kt and altimeter setting 1008;

- 19h38min38s: the YV2937 confirmed that it would continue the VOR Y approach to runway 29 and questioned the weather conditions at the Aerodrome;

- 19h38min41s: the TWR-EG informed that the meteorological conditions were visual (VMC);

- 19h38min45s: the TWR-EG complemented, informing light rain in the middle of the approach, through the tower;

> "Aah sir just aaa we have aaa light rain here in the middle of aa the approach, ok? In the abeam of the tower."

- 19h41min43s: the TWR-EG reported authorized landing on runway 29, with 180° wind and 16kt, with altimeter setting 1008;

- 19h41min54s: the YV2937 collated the authorized landing information;

- 19h41min59s: the TWR-EG confirmed the comparison of the YV2037 and reported wet runway;

> "Correct sir, wet runway."

After 19h44min33s, the YV2937 attempted to contact the TWR-EG three times, but the transmissions did not complete.

- 19h44min58s: the TWR-EG authorized the landing of the YV2937 on runway 29;

- 19h45min00s: the YV2937 tried to make contact with the TWR-EG, but the message was unintelligible;

- 19h46min13s: the TWR-EG informed that the landing was at 43min and authorized the taxi by Taxiway A until position G13;

The YV2937 tried to make contact two more times, not being understood by the TWR-EG.

- 19h47min15s: the TWR-EG asked the YV2937 if the runway had been released;

- 19h47min17s: the YV2937 reported that the runway had not been cleared and that an excursion had happened;

> "Negative, we run out of the runway, we run out of the runway."

- 19h47min25s: the TWR-EG asked the YV2937 to wait a minute and questioned if they wanted any support to be called;

> "Ok sir, stand by one minute. Do you want to call aa any aa support?"

- 19h47min32s: the YV2937 confirmed that support would be needed and that they were off the runway, after threshold 11;

> "Affirm, we need support, we are out of the runway, of the final of the runway one one."

- 19h48min13s: the TWR-EG reported that it had made contact with the firefighters and with the Infraero and questioned whether the YV2937 needed any other assistance;

> "We contact now aa the firefighters and the Infraero. Aaa confirm if you want to call any other aid."

- 19h48min28s: the YV2937 reported that it was "OK", but that it was out of the runway, with a hydraulic breakdown and requested the firefighters, but they are not sure about it;

> "Aa no we are ok, but we are out of the runway, we hydraulic failure, we run out of the runway. We need request aa maybe the firemen, I don't know."

- At 19h51min20s: the YV2937 asks if the TWR-EG has activated the firefighters and informs that it needs support;

> "Did you call some the firemen? Or… we need a ground support here."

- 19h51min24s: the TWR-EG does not understand the message and asks the YV2937 to confirm it;

- 19h51min26s: the YV2937 asks if the firefighters were called and that it needs ground support, as they are off the runway;

> "Did you call the firemen? We need aa here the ground support we are out of the runway. Do you know?"

- 19h51min32s: the TWR-EG informs that the ground support has been called, through the firefighters and the Infraero; and

- 19h51min40s: the YV2937 confirms receiving the information and warns that it will keep position.

1.10 Aerodrome information.

The Aerodrome was international, public, managed by the Infraero and operated under Visual Flight Rules (VFR) and by Instruments (IFR), during day and night.

The runway was made of asphalt, with thresholds 11/29, dimensions of 2,700m x 45m, with an elevation of 262 feet.

At the moment of the occurrence, there was the Category 9 fire alert service, that is, it was able to serve aircraft with a total length between 61 and 76m, excluded.

At that time, the largest aircraft in operation was the Boeing 747-800F, whose operation was to follow special procedures, described in the MOPS.

Still, with regard to the operation of the Aerodrome, it was included in the MOPS, in its latest version, from 08NOV2018, in item 12 - Monitoring of the Aerodrome's physical and operational condition:

> "12.1 Monitoring Procedures
>
> In order to ensure monitoring of the Aerodrome's physical and operational condition, the Traffic Coordination, represented by the Traffic Officers and Apron Inspectors, adopts the following procedures:
>
> a) Monitor the operational area in order to identify the existence of obstacles that violate the Aerodrome's protective surfaces and that may directly impact aircraft operation;
>
> ...
>
> i) Monitor the presence in the movement area of contaminants on the pavement, debris or FOD, obstructions, fauna and obstacles;"

Such procedures were standardized by the RBAC 153 and included periodic inspections of the movement area, whose purpose was to ensure that the existing airport infrastructure offered safe conditions for continuous operation.

Thus, it was expected that, under normal conditions, four daily inspections would be carried out, according to the schedule: Dawn (before sunrise), Morning, Afternoon and Night (after sunset).

In addition to the periodic inspections, it was provided, in item 12.2.12, Inspections of the Movement Area - Special:

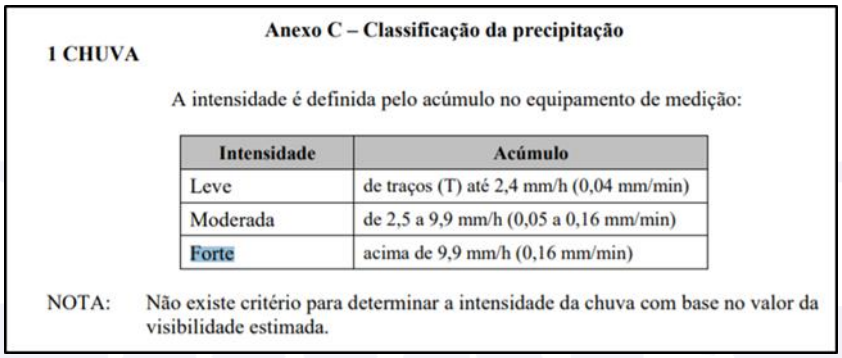
> "Special Inspections must be carried out after the following situations:
>
> a) Occurrence of Storms, Windstorms or Floods on the runways and taxiways;"

There was also, according to item 12.2.13 Special Inspection of Water Level Measurement:

> "a) The special inspection of water level measurement on the landing and takeoff runway must be carried out after the occurrence of heavy rains (precipitation above 25 mm/h) and whenever requested, by the aircraft commander or the TWR- EG;
>
> ...
>
> d) The COA must check with the DTCEA-EG - EMS meteorological area by calling 3652-5950 / 47 (H24) for the amount of precipitation (mm/h).
>
> ...
>
> h) If the point (s) where there are puddles with an area greater than 2m² and a water depth greater than 3mm are identified, each point must be registered with indication of the location on a grid map and later forwarded to the Supervisor from the Airport, for transfer to the maintenance area to take action;
>
> i) In the following cases, the Airport Supervisor must request a NOTAM for a runway "Slippery when wet";
>
> • When verified, through inspection, the existence of puddling with a thickness of water depth greater than 3mm in a continuous area greater than 50m²;
>
> • When verified, through inspection, the existence of puddling with an average water depth greater than 3mm in area (not continuous), the average depth of a region of 150m in length by the width of the runway is taken) using as a reference the central axis of the runway painting, beacons, piles, etc.
>
> ...
>
> e) After the Inspection is completed, the Traffic Officer or his replacement must complete the Special Inspection Form, attached below, and register with LEO, in the field: Inspections - Special."

As reported by the Aerodrome Operator, there was no information regarding the performance of special inspections for water level measurement.

The ICA 105-15, of 20APR2018, edited by the DECEA, which dealt with Surface Weather Stations (EMS), in its Annex C - Precipitation Classification, defined as “Heavy” rain with an index above 9.9mm / h (Figure 3).



Anexo C – Classificação da precipitação

1 CHUVA

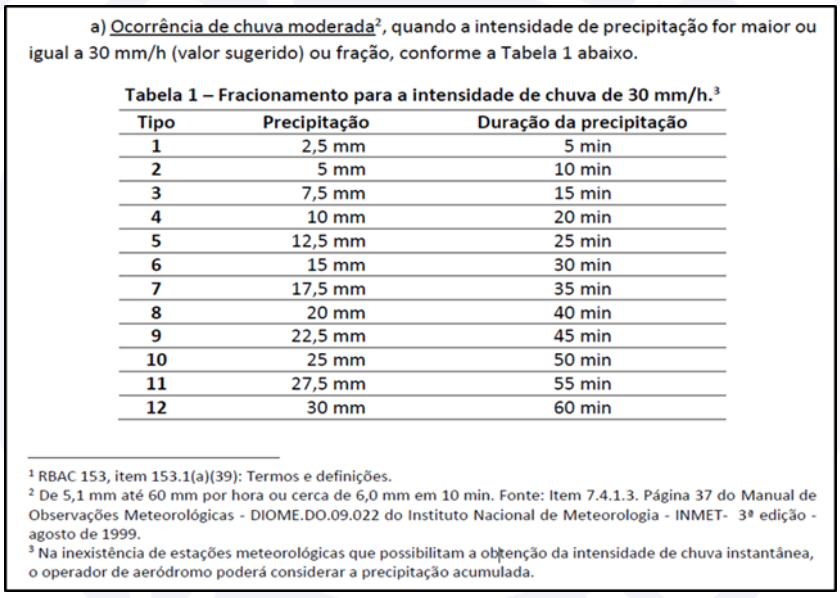
A intensidade é definida pelo acúmulo no equipamento de medição:

Intensidade	Acúmulo
Leve	de traços (T) até 2,4 mm/h (0,04 mm/min)
Moderada	de 2,5 a 9,9 mm/h (0,05 a 0,16 mm/min)
Forte	acima de 9,9 mm/h (0,16 mm/min)

NOTA: Não existe critério para determinar a intensidade da chuva com base no valor da visibilidade estimada.

Figure 3 - Extract from the ICA 105-15/2018, Annex C.

The ANAC, through the Alert to Aerodrome Operators n°002/2015, recommended the operator to define practical situations to check the depth of the water on the runway, so that a special inspection could be carried out when the intensity of precipitation was equal to or greater than 30mm/h, which was considered of “moderate” intensity, as shown in Figure 4 below:



a) Ocorrência de chuva moderada[2], quando a intensidade de precipitação for maior ou igual a 30 mm/h (valor sugerido) ou fração, conforme a Tabela 1 abaixo.

Tabela 1 – Fracionamento para a intensidade de chuva de 30 mm/h.[3]

Tipo	Precipitação	Duração da precipitação
1	2,5 mm	5 min
2	5 mm	10 min
3	7,5 mm	15 min
4	10 mm	20 min
5	12,5 mm	25 min
6	15 mm	30 min
7	17,5 mm	35 min
8	20 mm	40 min
9	22,5 mm	45 min
10	25 mm	50 min
11	27,5 mm	55 min
12	30 mm	60 min

[1] RBAC 153, item 153.1(a)(39): Termos e definições.
[2] De 5,1 mm até 60 mm por hora ou cerca de 6,0 mm em 10 min. Fonte: Item 7.4.1.3. Página 37 do Manual de Observações Meteorológicas - DIOME.DO.09.022 do Instituto Nacional de Meteorologia - INMET- 3ª edição - agosto de 1999.
[3] Na inexistência de estações meteorológicas que possibilitam a obtenção da intensidade de chuva instantânea, o operador de aeródromo poderá considerar a precipitação acumulada.

Figure 4 - Extract from the Alert to the ANAC’s Aerodrome Operators 002/2015.

In addition to this assessment methodology, the ANAC recommended, if the runway was considered contaminated, that is, when the average depth of water on the runway was equal to or greater than 3mm in a region of 150m long by 12m wide in the central portion concerning the runway axis, this information was passed on to the ATS agency, so that the airmen could receive it.

As for the MOPS, as noted earlier, in its item 12.2.13, it considered the precipitation intensity predicted for the measurement of 25mm / h.

As mentioned, the Aerodrome Operator had only one record of the Special Inspection of Water Level Measurement, carried out on 28NOV2018, shortly after the occurrence.

It was found out with the EMS-EG that, between October and December 2018, there were five occurrences of rain, the intensity of which exceeded the parameters foreseen for carrying out the Special Inspection of Water Level Measurement by the Infraero's MOPS, as shown in Figure 5 bellow:

Data	Horário (local)	Precipitação	Duração
19/10/18	12:00	29.6 mm	60 min
27/10/18	09:00	29.4 mm	35 min
07/11/18	17:00	53.6 mm	50 min
07/11/18	18:00	160 mm	50 min
28/11/18	16:00	24.6 mm	30 min

Figure 5 - Rainfall index measured by the EMS-EG rain gauge between October and November 2018.

In addition to the information contained in the MOPS, the derubberization, macrotexture and friction measurement reports were consulted, without any abnormality being detected.

1.11 Flight recorders.

The aircraft was equipped with a Flight Data Recorder (FDR) Fairchild, Model F1000, PN S603-10000-00, SN 00428 and a Cockpit Voice Recorder (CVR) Fairchild, Model A100A, PN 93-A100-80, SN 59096.

The recorders were taken to the CENIPA, in Brasília, to download the stored data and communications made by the crewmembers in the cockpit.

Regarding the CVR, no record was obtained, as the equipment, despite being receiving electrical current, it was not operational internally, so it was not possible to obtain any information.

The FDR data could not be interpreted at the CENIPA, as that Center did not have the necessary equipment for its transcription. Thus, the raw data was sent to Boeing, in the United States of America. However, the data was not fully validated by the manufacturer, as some information was corrupted, so that the results obtained could not be used for the analysis of this occurrence.

1.12 Wreckage and impact information.

The aircraft overpassed the end of runway 29 by 100 meters, coming to a stop with the landing gear on soft ground (dirt).

During the runway excursion, the landing gear collided with three Runway End Identifier Lights (REIL) and an Approach Light System (ALS) (Figure 6).

Figure 6 - Sketch with the final position of the aircraft and damage caused to the SBEG runway marking.

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.

YV2937 crew:

The commander started his Airline operational life on the Boeing 737-200, but he also flew the Boeing 737-400. In addition, he was able to fly the WW24 aircraft.

The commander reported being a person who did not like tense environments. Therefore, in the management of the cabin, he preferred to guide and help the copilot, and not just impose his will. In addition, he mentioned being quiet, sociable and hardworking.

On 26NOV2018, he had taken the same route Caracas / VEN - Manaus / BRA. The previous flight, carried out on 27NOV2018, on the Caracas / VEN - Barcelona / VEN leg was on a B737-400 aircraft and had a duration of 40 minutes. As the following day, 28NOV2018, he was scheduled for the flight Caracas / VEN-Manaus / BRA, and he returned from Barcelona to Caracas as a passenger.

In an interview, the pilot reported that it was the first time in his operational experience that a runway excursion happened. He learned that a similar situation occurred two years earlier with another aircraft of the company and of the same model, so that this failure started to be trained in a simulator.

Regarding the flight that originated the occurrence, the commander stated that he used the checklist for landing procedures, however, he considered it not necessary to declare an emergency, despite the failure in the hydraulic system.

The copilot experienced a situation similar to this occurrence, in 2016, on a flight from the leg Caracas / VEN - Curaçao / ARU, in which there was the loss of System A. In this situation, it was not raining and the two reversers worked.

The copilot also informed that the failures identified during the flight were reported and, on the ground, the maintenance team stated that “everything was within the parameters”. However, in flight, the failure occurred again.

He had already performed other flights with the commander, including on the Caracas-Manaus leg, and assessed the cabin environment as stable.

TWR-EG Traffic Controllers:

In the TWR-EG operation, operators worked in shifts, consisting of two hours and twenty minutes of rest, two hours and twenty minutes in the control function and two hours and twenty minutes in the assistant function, making a shift of seven hours total.

At each shift there were three operators, all with minimal English proficiency ICAO 3. At the time of the occurrence, the operator with ICAO 5 was at rest, the one in control had ICAO 3 and the one in assistance, ICAO 4.

While the aircraft was in contact with the APP-MN, checking the hydraulic failure, there was a change in wind, which started to favor the operation of runway 11.

Shortly after, the aircraft started approaching runway 29, being informed by the tower that the wind was already with a tail component. The YV2937 pilots did not report any hydraulic problems to the tower or even the need for ground support.

During the final approach, the TWR-EG reported that the Aerodrome was operating under VMC. However, as raised in interviews with the team that was on duty in the tower at that time, the visualization of the runway, as well as, specifically, in the threshold area 11, was not good due to the intensity of the rain, being necessary the use of binoculars to view the aircraft off the runway.

After landing and after the tower questioned whether the aircraft had cleared the runway, the pilot reported that he had left the runway just “a little”. In the tower, the emergency button could not be activated, as the siren was not working. The airport's SCI and the Infraero's COE were then called by telephone.

At no time was the radio used to activate the SCI and more than one phone call was required until the event was actually displaced, which only occurred ten minutes after the runway excursion. This delay probably occurred due to the fact that support was not requested during the telephone call, only that the SCI should remain on standby.

1.14 Fire.

There was no fire.

1.15 Survival aspects.

Although the aircraft left the runway and stopped on soft ground, an emergency evacuation was not carried out. After the total stop, the crew made contact with the tower, which triggered Infraero which, in turn, in coordination with the crew, provided a ladder for the occupants to disembark, with the aircraft stopped off the runway.

According to the SBEG Emergency Plan (PLEM), updated on 05NOV2018, item 3.1.1.2 - Aeronautical Emergency at the Aerodrome - Relief Condition (Immediate intervention):

> “a) Control Tower (TWR)
>
> Activate by order the SCI and COE, transmitting the following data:
>
> • Characteristic of the emergency;
>
> • Place of the accident or probable accident;
>
> • Runway to be used;
>
> • Aircraft type;
>
> • Aircraft registration;
>
> • Aircraft operator;
>
> • Number of people on board;
>
> • Type of material transported;
>
> • Other information deemed necessary.
>
> Confirm, with the SCI and the COE, if the information was received by those agencies;
>
> • Monitor the evolution of the event;
>
> • Proceed in accordance with your operational rules.
>
> b) Counter-fire section - SCI:
>
> Act according to PCINC.”

Regarding the actioning of the Fire Section at the Eduardo Gomes Airport (SCI-EG) in the event of an emergency, the MPCINC, updated in August 2018, provided that:

"2. COMMUNICATION PROCEDURES

a) TWR to SCI

Activations are carried out through siren, radio or telephone to respond to emergency situations, accidents, training and equipment testing, as follows:

...

UHF radio frequency

In case of inoperativeness of the audible alarm system (Siren), the TWR calls the SCI communications room via radio, whose call code is “SCI” and reports the type of situation to be actioned by the SESCINC, giving a brief report of the type of occurrence.

In the case of an aeronautical emergency which requires positioning for immediate intervention or intervention, the TWR must at least pass on the following information:

• Threshold to be used for landing;

• Failure presented on the aircraft;

• Aircraft type;

• Number of people on board;

• Quantity of fuel; and

• Prefix.

...

The TWR-EG sounds the siren, always immediately after becoming aware of an aeronautical emergency in its jurisdiction, regardless the reported alert level (Positioning for intervention or immediate intervention).”

However, the red emergency button installed on the TWR-EG, which triggered the siren, was not activated because it was inoperative, with all contacts made by telephone.

Thus, to understand the dynamics of the response to the serious incident that occurred with the YV2937, through the activation of the SCI-EG and the Infraero’s COE, the recordings of the telephone communications made between the TWR-EG and these agencies were surveyed:

- At 19h47min (UTC), after being aware of the YV2937 runway excursion, the TWR-EG contacted the Infraero’s COA and reported on the incident, being required, at that moment, for ground support;

- At 19h48min (UTC), contact was made with the SCI-EG and the occurrence was reported, without requesting support, only that the service should remain “QAP”. (QAP is a code language, corresponding to “keep listening”);

- At 19h49min (UTC), the TWR-EG contacted the Infraero and questioned about the delay in handling the incident;

- At 19h50min (UTC), the SCI-EG contacted the TWR-EG and asked if it should remain in “QAP”. At that moment, the tower requested that the displacement to aid the occurrence took place;

- At 19h52min (UTC), the TWR questioned the SCI-EG the reason for the delay, informing that no vehicle had requested a displacement to the location of the incident; and

- At 19h53min (UTC), the SCI-EG contacted the TWR-EG and questioned at which threshold the aircraft was and, after receiving this information, it confirmed the departure of the support vehicles to attend to the occurrence.

Also, according to reports from the tower and corroborated by the crew, the emergency team took approximately ten minutes after the runway excursion to get to the aircraft.

1.16 Tests and research.

As noted in the maintenance manuals, the Pressure Transmitter System A, PN ST-107R was not expected to undergo any maintenance intervention, since it did not have a TLV or even TBO.

In this way, the Pressure Transmitter would only undergo maintenance intervention, after experiencing a failure or appearing to be no longer operational, a maintenance process known as Condition Monitoring.

It was sought, together with aircraft maintenance companies certified by Boeing in Brazil, to perform examinations, tests and research, with the objective of detecting the reason that allowed the leakage of hydraulic fluid through the body of the Pressure Transmitter, however, companies with technical capacity were not found to perform such examinations.

1.17 Organizational and management information.

The company Avior Airlines C.A., operator of the aircraft, was of Venezuelan nationality and performed commercial air transport of passengers and cargo.

The Avior Airlines' Operational Safety Management and Maintenance Organization presented, through the different manuals, the procedures and policies required by the Venezuelan Civil Aviation Authority, namely: Operations Manual, Emergency Procedures Manual and General Program of Training, Selection and Development of Personnel.

As collected in the interviews and demonstrated through documents, Avior was a strict company in terms of training in the simulator and there was a frequent evaluation of pilots and copilots. Crew Resource Management (CRM) was also carried out annually by the company.

According to the information obtained, the last Boeing 737-200 simulator training conducted by the commander took place in August 2018.

According to the data obtained during the investigation, in addition to the training offered, there were also explicit guidelines on how to comply with the procedures.

1.18 Operational information.

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

Air Traffic Control:

Based on the documents and legislation in force, provided by the control agencies of the DTCEA-EG, and by interviews with the controllers who were on duty at the TWR-EG at the time of the occurrence, it was found that the YV2937:

- contacted the APP-MN and was instructed to descend to 4,000ft, at the heading of the waypoint DAGTI, to execute the VOR Y approach procedure for runway 29;

- requested that the APP-MN confirm the runway in use in SBEG and was informed that, at that moment, threshold 29 was being used;

- it was contacted by the APP-MN, approximately 5 minutes after his first contact, being informed that the wind was 170°/08kt;

- continued on the approach and, after being authorized by the APP-MN to perform the VOR Y procedure of runway 29, requested to make a 360° turn, due to hydraulic problems. At the end of the maneuver, the aircraft reported being ready for the approach and, after receiving the proper authorization, it was instructed to call the TWR-EG for landing;

- contacted the TWR-EG and received authorization for landing at threshold 29, having been informed that the wind, at that time, was 180°/14kt. It is worth mentioning that at that moment the threshold in use in SBEG was already the number 11; and

- it asked the TWR-EG about the meteorological conditions at the Aerodrome and it was informed that SBEG operated under Visual Meteorological Conditions (VMC), with light rain in the middle of the approach.

Subsequently, the TWR-EG confirmed the landing authorization for the YV2937, updated the wind information to 180°/16kt and reported that the runway was wet. It should be noted that, at the moment of landing, it was raining heavily on the field.

The YV2937 proceeded for landing, crossed the final limit of threshold 11 and requested ground support.

In view of the scenario, the TWR-EG immediately contacted the Infraero and the SCI to provide the proper assistance to the YV2937.

Aircraft Operation:

It was a regular flight, Avior 1272 (ROI1272), operated by the Venezuelan company Avior Air Lines, which departed from SVMI to SBEG. The flight was carried out on FL310, the descent and preparation for approach, as well as the contact with the APP-MN, were performed without any abnormality.

According to the weight and balance manifest, the SVMI took off with 105,693lb. During the flight, 15,213lb of fuel were consumed and the landing on SBEG was carried out with 90,480lbs, values within the weight and balance limits specified by the manufacturer.

During the approach to SBEG, when starting the speed reduction and the aircraft configuration for the VOR Y approach to runway 29, shortly after the Flap was commanded to position 5, the CAUTION light was turned on, followed by the LOW PRESS lights - HYD PUMPS and LOW PRESS - FLT CONTROL A.

Immediately, the crew members verified, on the multiple hydraulic pressure indicator, that the pressure of System A had dropped to zero, as well as the amount of hydraulic fluid in the reservoir of that system had dropped.

The indicators for the amount of hydraulic fluid in the System A reservoir and the hydraulic pressure for the “A” and “B” brakes can be seen in Figure 7, below, as found by the Investigation Team after landing on SBEG.

Figure 7 - Indicators of the amount of hydraulic fluid in the reservoir and hydraulic pressure of the “A” and “B” systems, after landing on SBEG.

The crewmembers asked the APP-MN to perform a “360” in the current position, that is, to hold in the position they were in to solve the crash before landing.

The QRH - Loss of System A, page 13.2, Highlighting the following items:

> Loss of System A
>
> Condition: Hydraulic system a pressure is low.
>
> 1 System A - FLT CONTROL Switch ……. Confirm …… STBY RUD
>
> 2 System A - HYD PUMP switches (both) …….. OFF
>
> 3 Plan a flaps 15 landing.
>
> 4 Set VRef 15.
>
> 5 Plan to extend flaps to 15 using alternate flap extension.
>
> …
>
> 6 Plan for manual gear extension
>
> …
>
> 7 Check the Non-Normal Configuration Landing Distance table in the Advisory Information section of the Performance Inflight Chapter.

After the initial guidelines, the checklist informed the crew which items were inoperative, due to the low pressure in Hydraulic System A:

> Note: Inoperative Items
>
> …
>
> Trailing edge flaps normal hydraulic system inop
>
> The trailing edge flaps can be operated with the alternate electrical system. Alternate flap extension time to flaps 15 is approximately 2 minutes.
>
> Leading edge flaps and slats normal hydraulic system inop
>
> The leading edge flaps and slats can be extended with the standby hydraulic pressure. Once extended, they cannot be retracted.
>
> Normal Landing gear extension and retraction inop
>
> Manual gear extension is needed.
>
> Ground Spoiler inop
>
> Landing distance will be increased.
>
> Inboard brakes normal hydraulic system inop
>
> Inboard brakes have accumulator pressure only.
>
> Both thrust reversers normal pressure inop
>
> Thrust reversers will deploy and retract at a slower rate.
>
> Nose wheel steering inop
>
> Do not attempt to taxi the airplane after stopping.

To perform the lowering of the flaps, the alternate mode (Alternate Flap Extension) was used, according to the QRH procedure. The control lever was placed in the Flaps 15 position and the Alternate Flaps switch was turned to the down position. The flaps started to move, but did not complete the movement until the selected position, stopping at the immediately previous position, Flaps 10.

This failure was addressed by the QRH, page 9.3 - item Trailing Edge Flap Disagree, whose condition was (Figure 8):

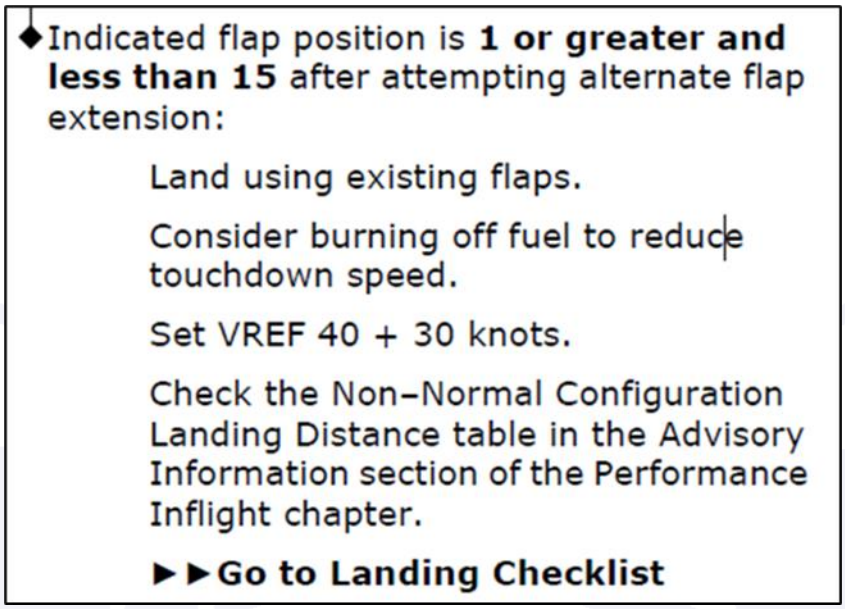


Figure 8 - Alternate Flap Extension procedures.

For lowering the landing gear using the manual system (Manual Gear Extension), the procedure was performed according to the QRH with satisfactory results, since the three power legs lowered and locked.

In an interview, the crew reported having approached runway 29 in SBEG, using a 144kt VRef, that the touch was performed in the Touch Down Zone (TDZE) and, immediately, the brakes and reversers were activated.

In an attempt to corroborate the aircraft's touch point information, the Infraero's CCTV cameras were checked, however, due to the rain falling at the time, it was not possible to say whether the touch actually occurred at the TDZE.

Considering a landing weight of 90,000lb and the data contained in the VREF (KIAS) table, available on the PI-QRH 30.5 page, the predicted speed for a normal final approach, with Flap 40 (VRef 40) was 121kt. However, due to the “Trailing Edge Flap Disagree”, with the Flaps in position 10, the speed to be flown on the final approach, according to the QRH on page 9.3, was VRef 40 + 30, that is, 151Kt.

Through the information collected by the approach radar of the DTCEA-EG, it was possible to elaborate Figure 9 below:

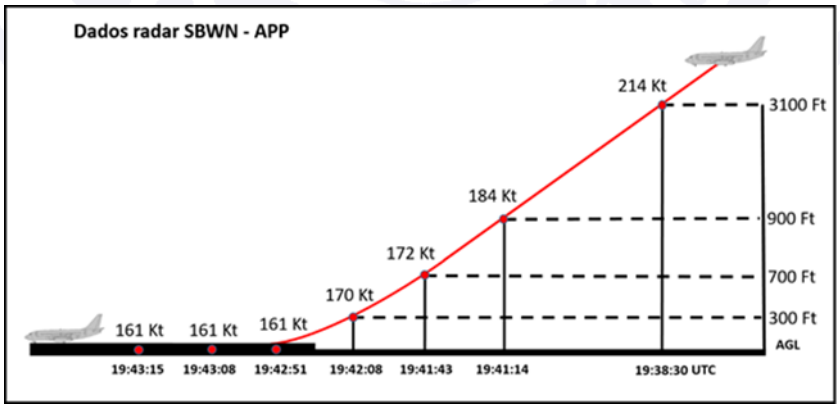


Figure 9 - Graph prepared with information recorded by the Manaus Control Approach Radar (SBWN - APP).

The FCOM, contained in its chapter Performance Inflight (PI), page PI 15.8 - Slippery Runway Landing Distance:

> "Landing distances are the real landing distances and do not include the regulatory factor of 1.67%. Therefore, they cannot be used to determine the length of the airfield required for dispatch. When landing on slippery runways or contaminated with ice, snow, mud or standing water, the reported braking action must be considered. If the surface is affected by water, snow or ice and the braking action is reported as "good", we should not expect conditions as good as on clean, dry tracks. The "good" rating is comparative and it is intended to mean that airplanes should not experience braking or directional control difficulties when landing. The level of performance used to calculate the 'good' rating is consistent with the wet runway tests done on the first Boeing jets. The level of performance used to calculate "bad" ratings is due to runways covered by wet ice. Read the landing distance for the braking action reported with the airplane weight and then apply the adjustments for airport pressure altitude and approach speed, as needed."

Considering that there were no previous reports of braking difficulty or slippery runway in SBEG, the braking action, for runway 29 in SBEG, was considered as good (good reported braking action), for the purpose of landing distance calculations, in the time of the occurrence.

Continuing the information about the operation with a slippery runway, the FCOM brought, on page PI 15.8 - Non-normal Configuration Landing Distance:

> "... Landing distances are shown for dry runways, with braking action reported as good, medium and bad. Each abnormal configuration is listed with its respective recommended approach speed ..."

As directed by the QRH, the distance chart for landing in abnormal conditions or "Non-Normal Configuration Landing - Good Reported Braking Action", was available on the PI-QRH 11.8 page (Figure 10):

Non-Normal Configuration Landing Distance
Good Reported Braking Action

		LANDING DISTANCE AND ADJUSTMENT (FT)							
		REF DIST FOR 100000 LB LANDING WEIGHT	WT ADJ PER 5000 LB ABV/BLW 100000 LB	ALT ADJ PER 1000 FT ABOVE SEA LEVEL	WIND ADJ PER 10 KTS		SLOPE ADJ PER 1%		APPROACH SPEED
LANDING CONFIGURATION	VREF				HEAD WIND	TAIL WIND	DOWN HILL	UP HILL	PER 10 KTS ABOVE VREF
TRAILING EDGE FLAP ASYMMETRY (1≤ FLAPS <15)	VREF40+30	4300	160 / -150	290	-160	580	70	-70	250

Figure 10 - QRH extract, page PI-QRH 11.8 - Non-Normal Configuration Landing Distance.

Based on the information registered by the Approach Radar, the information on the chart "Non-Normal Configuration Landing - Good Reported Braking Action", page PI-QRH 11.8 and other parameters observed in that approach, namely: Flap Asymmetry (1≤ FLAPS <15); landing weight of 90,000lb; 5kt tailwind component; VRef higher by 20kt (170kt); condition of wet runway (Good Braking Action) and maximum manual braking, the required landing distance of 1,463 meters was met.

Also, according to the crewmembers, the braking was not effective and the number 1 reverser did not start functioning, being available for braking the aircraft only the external brake sets (Outboard brakes) and the number 2 reverser (Right engine).

According to the QRH - Loss of System A, Page 13.2, the operation with only the "Outboard brakes" was already expected, since the "inboard" brake system operated with the hydraulic pressure coming from System A, which was inoperative at that time. In addition, in this same topic of the QRH, it was informed that the reversers would open at a slower speed than normal.

The factors mentioned were already foreseen by the manufacturer in its operating manual, however, the failures, as they occurred at the time of landing, that is, concomitant with “Loss of System A” and “Trailing Edge Flaps Disagree”, were not approached in a combined manner, which made it impossible for a precise calculation of the landing distance, under these conditions, to be performed.

In addition to the inoperability of the previous systems, there was also the inoperability of the steering system, which is fundamental for the taxiing of the aircraft after landing.

The aircraft traveled the entire length of runway 29 and stopped about 100 meters after its rear limit.

1.19 Additional information.

Changing the threshold in use

Regarding the process of changing the threshold in use, which occurred due to the change in the direction and speed of the wind (270°/07kt to 170°/08kt), the APP-MN did not consider the need to redirect the YV2937 aircraft to the runway in use, given the new wind configuration.

Although the ICA 100-37 / 2018, in item 6.5.2, recommended that the aircraft would normally land or take off against the wind, unless the air traffic safety conditions or the runway configuration determined a different direction. It is worth mentioning that the APP-MN, at no time, informed the YV2937 of the change of threshold.

It is important to clarify that, still according to the ICA 100-37/2018, item 6.5.6, if the pilot in command of the aircraft considered that the runway in use was not appropriate for the operation that he would have to perform, he could request authorization to use another runway.

According to the ICA 100-37/2018, item 6.5.9, the Control Agency was only allowed to choose the threshold that offered greater advantages when the wind on the surface was below 10km/h (6kt).

Runway conditions assessment

The Appendix 14, in item 2.9, determined that the conditions of the movement area, including the presence of water on the runway, should be monitored and reported to the ATS when they affect aircraft operations, in order for the parties involved to take appropriate actions, both for landing and for takeoff.

Taking into account the existence of specific criteria for the characterization of the runway, such as DRY, WET, WET or CONTAMINATED, it was found that the TWR-EG informed the YV2937 that the runway was wet, without having received any information from the Infraero with the proper classification of the state of the runway.

It is worth mentioning that the information provided by the Control Tower regarding the status of the runway in use, were treated in the MCA 100-16/2018 as complementary information, and the phraseology examples contained in that manual referred to information originated in the aircraft that had landed or from the Aerodrome Administration, as per item 4.1.15 of the aforementioned standard.

Aircraft view at threshold 11

The Air Traffic Controllers (ATCO) were unable to verify that the aircraft had passed the end of the runway, since the position of the tower made it difficult to see.

This condition worsens considerably in situations of weather degradation and, in these cases, even with the use of binoculars, the controllers were unable to visualize the

movement of aircraft at threshold 11. This configuration impacted the tower's response time for possible situations of emergency.

In view of this scenario, the DTCEA-EG requested an evaluation by the Infraero regarding the installation of cameras at threshold 11 to mitigate the problem and received the following response from the Infraero:

> "… It is necessary to identify an Optical Fiber with 01 (one) Pair of Tracks available to activate the Optical Backbone for the Installation and Activation of the Network Point in order to attend the installation of the Monitoring Camera; and
>
> ... for the activation of the Optical Backbone, it is necessary that the DTCEA-EG acquires 02 (two) 10/100 Single Mode Optical Converters. It was suggested the Manufacturer Intel Brás and the Model: KFS1120 (Fast Single Mode Media Converter 20Km). This converter model is already in production, serving the Optical Backbones of the DTCEA-EG Tower with the Passenger Terminal 1 and the AIS Room with the DTCEA-EG Technical Room."

Code Q usage

Another relevant fact was observed, related to the communication carried out between the TWR-EG and the SCI of the Aerodrome. The tower called to the SCI and reported the occurrence involving the YV2937, but when asked by the SCI if "it was just to stay QAP", the tower replied yes, demonstrating not knowing the meaning of this code.

Note of item 2.20.2 of the MCA 100-16/2018:

> "The spoken Q code groups, which, due to their frequent use, have already become part of the aeronautical terminology, can be used where they provide a more suitable alternative to long and complex sentences."

It was also reported by the ATCO of the TWR-EG the existence of a red button in the Tower premises that, when pressed, activated an alarm in the SCI. However, this button was inoperative on the date of the occurrence.

1.20 Useful or effective investigation techniques.

Nil.

2. ANALYSIS.

It was a passenger transport flight.

Until the approach for landing, the flight went on without any abnormality. When starting the aircraft configuration, immediately after placing the flap control lever in position 15, there was a drop in the hydraulic pressure of System A, which was responsible for providing hydraulic energy for the movement of the flaps, as well as for other aircraft systems.

After the loss of pressure, the crewmembers realized that the amount of hydraulic fluid in the reservoir of that system had dropped to "zero", that is, there was no more hydraulic fluid in System A.

In view of this, the APP-MN was asked to wait in the position where they were to solve the failure, which was authorized by the control. The crew then proceeded to read the QRH - Loss of System A.

During the execution of the Checklist "Loss of System A", the flaps were commanded to position 15, through the alternate system, however, the flaps lowered only to position 10.

After that, the landing gear was lowered by the emergency system, successfully confirmed by the three green lights on, indicating that the three landing gears were lowered and locked.

For the calculation of the reference speed (VRef), the crewmembers reported having used the QRH, obtaining approximately the speed of 144kt, however, the procedure for Loss

of System A indicated that a speed of VRef 40 + 30 should be used, which, under those conditions, would be 150kt.

In the radar visualization provided by the APP-MN, it was observed that the final approach was flown with a speed on the ground of 170kt, about 20kt above the speed stipulated by the QRH. It is possible that part of that speed was caused by the wind component, which, at that time, was approximately 5kt tail.

The available weather information indicated that there was moderate rain on the runway. However, this condition was not passed on to the crewmembers, since the TWR-EG was limited to communicating that there was “light rain through the tower”.

During the investigation, it was found that this information was inaccurate, since, corroborated by the CCTV images of the airport administrator and the measurement performed by the EMS-EG rain gauge, the amount of rain that fell at that moment was not light, according to the ICA 105-15.

This fact showed that, possibly, the TWR-EG's perception of the weather conditions was inaccurate, which led to a misinterpretation regarding the intensity of the rain at that time.

In addition, the TWR-EG already had the information that the prevailing wind was favorable for landing on runway 11 and not on runway 29, but it did not inform the crew of the possibility of tailwind, serving only to transmit the reading of the present wind.

Thus, the runway change process failed, since the YV2937 was never informed that the threshold in use had become the 11. Both the TWR-EG and the APP-MN stopped transmitting this information to the YV2937, which could be crucial for the safe landing of the aircraft, given the direction and intensity of the wind (180°/16kt) informed by the TWR-EG in the landing authorization.

Possibly, due to the high workload to which they were subjected at that time, the pilots of the YV2937 did not pay attention to the fact that the wind informed by the TWR-EG, during the approach, indicated that the landing should be carried out on runway 11.

It is noteworthy that the meteorological conditions, combined with the hydraulic problem presented by the aircraft at that time, indicated that the landing might not occur satisfactorily, since most of the systems necessary for the aircraft's deceleration were inoperative.

Thus, it is possible that there was a decrease in the crew's situational awareness level, to the point of not being aware of the risks arising from the association between adverse weather conditions and the aircraft's inoperative systems, which, by themselves, already required additional care.

It is noted that the crew, before landing, did not declare an emergency or request any type of ground support, which reinforces the understanding that the pilots had not understood the gravity of the situation, since, according to the note “items inoperative” of the Loss of System A of the QRH, the aircraft could not be taxied by its own means.

As a result of the difficulties to understand the dynamism of that operation, the landing was made at a speed above the one predicted by the QRH, which resulted in an increase in the distance required to stop the aircraft.

In addition, only one reverser worked, which, added to the tailwind component, caused the aircraft to cover the entire length of the runway and cross the limit of the threshold 11, entering the grassy area and damaging the end of the runway markings.

The fact that the crew did not mention to the controllers the real situation to which the aircraft was subjected may have contributed to them not realizing that the flight needed additional care, including ground support.

The TWR-EG was unable to visualize the YV2937 aircraft passing the end of the runway, due to the position of the tower in relation to threshold 11, combined with the heavy rain present at the time of landing.

This delay in identifying this type of occurrence can be crucial in situations where the response time is essential for the support to be provided. The pilot himself, when asked if he had already cleared the runway, was the one who informed that he had exceeded his limit and needed support.

The MCA 100-16, in item 2.20.2, NOTE, established that the frequently used Q code groups, which were already considered a common part of the aeronautical terminology, could be used as a more adequate alternative instead of long and complex phrases.

In aviation, terminologies with the code “Q” are commonly used, in reference to the adjustment of the altimeter in relation to the ground, the average sea level and the local pressure, in addition to the codes QDM (Magnetic Heading) and QDR (Magnetic Marking) in the aerial radio navigation. These codes are used in radios with air traffic control agencies as an unambiguous abbreviation, where safety and efficiency are of vital importance.

It was found that there was no forecast for the use of the “QAP” code (waiting) by the tower, since the term was not an alternative for a long sentence, and the use of this code did not bring any operational gain in communications made with the Control Tower.

Still, in relation to the operation of Eduardo Gomes Airport, an attempt was made to identify how a Special Inspection of Water Level Measurement was carried out, which, according to the PLEM, should be performed whenever it rained more than 25mm / h.

There was also a failure of this procedure, reinforced by the fact that the Infraero did not have a rain gauge, therefore, it did not have access to the measurement of the rain that fell on the Aerodrome, having to consult the information available with the EMS-EG. However, there was no provision in the MOPS that such contacts would be made with that service.

According to a survey carried out with the EMS-EG, it was found that there was no record of special inspections performed by the Aerodrome operator on the day of the occurrence, despite the fact that during the months of October to December 2018, these inspections should have been carried out.

Regarding the execution of maintenance services on the aircraft, the sequence of non-conformities observed at the time of the failure of the Hydraulic System A, followed by secondary failures, such as the incomplete lowering of the flaps by the emergency system and failure to activate the #1 reverser, may have been caused by poor maintenance of these systems. However, this hypothesis could not be confirmed.

3. CONCLUSIONS.

3.1 Facts.

a) the pilots had valid CMAs;

b) the pilots had valid B732 aircraft type Rating (which included the 737-2Y5 model), IFRA Rating, and English Language Proficiency Certification;

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

d) the aircraft had valid CA;

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

f) the technical maintenance records were updated;

g) the weather conditions were favorable for landing on SBEG's runway 29;

h) there was heavy rain over SBEG, according to the ICA 105-15 classification;

i) the tail wind component, during the approach and landing phases, was approximately of 5kt;

j) there was failure of hydraulic system A;

k) flap 10 was used for landing;

l) reverser 01 did not operate;

m) the aircraft traveled 100 meters off the runway, on soft ground;

n) there was no activation of the SCI by the siren, according to the PLEM;

o) the aircraft had minor damage; and

p) all occupants left unharmed.

3.2 Contributing factors.

- **Control skills – undetermined.**

The inadequate application of flight controls may have contributed to the excess speed at which the aircraft approached for landing on SBEG, which required greater distance for the aircraft to stop.

- **Communication – a contributor.**

There were flaws in the communication process established between the crewmembers of the YV2937 and the TWR-EG, characterized by the lack of accurate information on the intensity of the existing rain, as well as on the change of runway threshold for landing operations.

These failures contributed to the landing on runway 29, with tailwind, favoring the runway excursion.

Thus, the control agencies were also unaware of the aircraft's failure condition, since there was no declaration of urgency or emergency, contributing to their failure to activate the ground support means as required by the Aerodrome Emergency Plan.

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

The distance required to stop the aircraft was increased due to the weather conditions present, as well as making it difficult to visualize the runway exit, by the TWR-EG, which culminated in the delay of the ground support means.

- **Crew Resource Management – undetermined.**

It is possible that an inadequate cabin coordination has caused the crewmembers to not realize that they were approaching the runway with tailwind, as well as that they did not observe, as recommended in the QRH, that the aircraft could not be taxied after landing, which could be corroborated by the fact that the crew did not request any ground support from the control agencies.

- **Use of phraseology by the crew – undetermined.**

The fact that the crew did not expressly declare that the landing would be carried out in a contingency situation may have made it possible that the other agencies involved in the operation could not provide the necessary support for the landing of the aircraft.

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

There was a failure in the transmission of meteorological information by the ATCO to the YV2937, not being informed that the threshold in use had already been changed to 11, which allowed the landing to be carried out on runway 29, with tailwind.

- **Piloting judgment – a contributor.**

There was an inappropriate judgment of the consequences inherent to the Loss of System A failure, mainly considering that the approach took place in adverse weather conditions and with tailwind, and without requiring any type of ground support.

- **Aircraft maintenance – undetermined.**

The sequence of failures observed at the time of the loss of the Hydraulic System A, followed by secondary failures, such as the incomplete lowering of the flaps by the emergency system and the failure to activate the #1 reverser, may have been caused by poor maintenance of these systems, however such a hypothesis could not be confirmed.

- **Perception – undetermined.**

A possible decrease in the level of situational awareness on the part of the crew may have created difficulties in adequately perceiving the adverse effects generated by the combination of the failures in the aircraft systems and the existing weather conditions.

Possibly, there was a misinterpretation about the severity of rain present at the Aerodrome, by the TWR-EG, which led to the transmission of inaccurate information to the crewmembers of the YV2937.

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

The inaccurate assessment of meteorological information and the impact of the hydraulic system failures culminated in the decision to proceed to landing at threshold 29, despite adverse circumstances, which favored the runway excursion.

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-177/CENIPA/2018 - 01 **Issued on 07/08/2021**

Work with the Eduardo Gomes Aerodrome Operator (SBEG), in order to optimize the flow of information about the amount of rain on the Aerodrome, so that the runway inspection is carried out in a timely and effective manner.

IG-177/CENIPA/2018 - 02 **Issued on 07/08/2021**

Work with the operator of the Eduardo Gomes Aerodrome (SBEG), so that its Fire Fighting Team avoids the use of the Q Code in communications with the TWR-EG.

IG-177/CENIPA/2018 - 03 **Issued on 07/08/2021**

Disclose the lessons learned in the present investigation, in order to alert Aerodrome operators with EMS (Surface Meteorological Station) about the importance of having an operationalized flow of information about the amount of rain on the Aerodrome, providing that the inspection of the runway is carried out properly and effectively.

To the Air Space Control Department (DECEA):

IG-177/CENIPA/2018 - 04 **Issued on 07/08/2021**

Act with the DTCEA-EG, so that its controllers perform the procedures provided for runway change, as soon as necessary, as well as that they communicate to the pilots relevant information such as the change of the runway in use, especially when it is related to weather conditions.

IG-177/CENIPA/2018 - 05 **Issued on 07/08/2021**

Disseminate the lessons learned in the present investigation, in order to alert the Airspace Control Detachments, which have Air Traffic Control Service, about the importance of their controllers, effectively, perform the procedures prevised for runway changing, as soon as it is necessary, as well as communicating the pilots relevant information, such as the change of the runway in use, especially when it comes to weather conditions.

IG-177/CENIPA/2018 - 06 **Issued on 07/08/2021**

Work with the DTCEA-EG, in order to provide the installation of CCTV cameras that allow the viewing of threshold 11 by the TWR-EG controllers.

IG-177/CENIPA/2018 - 07 **Issued on 07/08/2021**

Work together with the DTCEA-EG, so that its flight controllers avoid the use of the Q Code in internal communications, especially those carried out by telephony.

IG-177/CENIPA/2018 - 08 **Issued on 07/08/2021**

Disseminate the lessons learned in the present investigation, so that the flight controllers of the Airspace Control Detachments, which have Air Traffic Control Service, avoid using the Q Code in internal communications, especially those carried out by telephony.

IG-177/CENIPA/2018 - 09 **Issued on 07/08/2021**

Assess the possibility of standardizing the actions, by the Air Traffic Service or Control Agencies, in order to inform the Aerodrome Operator of the occurrence of rain with sufficient intensity to contaminate the runway, with the purpose that the operator receives the information in time for the runway inspection.

5. CORRECTIVE OR PREVENTATIVE ACTION ALREADY TAKEN.

None.

On July 8th, 2021.