COMANDO DA AERONÁUTICA

CENTRO DE INVESTIGAÇÃO E PREVENÇÃO DE ACIDENTES AERONÁUTICOS

FINAL REPORT
A - 132/CENIPA/2019

OCCURRENCE:	**ACCIDENT**
AIRCRAFT:	**PT-MHC**
MODEL:	**208B**
DATE:	**16SEPT2019**

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 16SEPT2019 accident with the 208B aircraft model, registration PT-MHC. The accident was classified as “[WSTRW] Windshear or Thunderstorm”.

The aircraft took off from the Eduardo Gomes Aerodrome (SBEG), Manaus - AM, to the Maués Aerodrome (SWMW) - AM to transport passengers, fulfilling the regular flight OWT5582.

Shortly after the take-off from threshold 29, the aircraft lost height and crashed in a wooded area to the left of the runway, 600 meters from threshold 11.

The aircraft had substantial damage.

One crewmember and three passengers suffered minor injuries and one crewmember, and five passengers suffered serious injuries.

An Accredited Representative of the Transportation Safety Board (TSB) - Canada, (State where the engine was manufactured and designed) was designated for participation in the investigation.

CONTENTS

GLOSSARY OF TECHNICAL TERMS AND ABBREVIATIONS

ANAC	Brazil's National Civil Aviation Agency
APP-MN	Approach Control - Manaus
CA	Airworthiness Certificate
CB	Cumulonimbus
CCO	Operational Control Center
CENIPA	Aeronautical Accident Investigation and Prevention Center
CFIT	Controlled Flight Into Terrain
CMA	Aeronautical Medical Certificate
CRM	Crew Resource Management
CU	Cumulus
DCTA	Aeronautics Science and Technology Department
DTCEA-MN	Air Space Control Detachment - Manaus
EGPWS	Enhanced Ground Proximity Warning System
EMBD	Embedded
EPL	Emergency Power Lever
FAB	Brazilian Air Force
FEW	Few (1 and 2 oktas)
GOES	Geostationary Operational Environmental Satellite
GSO	Safety Manager
ICA	Command of Aeronautics' Instruction
IFR	Instrument Flight Rules
IFRA	Instrument Flight Rating - Airplane
ILS	Instrument Landing System
INFRAERO	Brazilian Airport Infrastructure Company
INTSF	Intensifying
ISOL	Isolated
MAP	Dangerous Goods Manual
MEL	Minimum Equipment List
METAR	Meteorological Aerodrome Report
MGE	General Company Manual
MGM	General Maintenance Manual
MGO	General Operations Manual
MGSO	Safety Management Manual
MNTE	Airplane Single Engine Land Rating
NM	Nautical Miles
NOTAM	Notice to Air Missions
OWT	Name of the flight identifier of the company Two Air Taxi Ltd.

PGRF	Fatigue Risk Management Program
PCM	Commercial Pilot License – Airplane
PIC	Pilot in Command
PLA	Airline Pilot License – Airplane
PPR	Private Pilot License – Airplane
PPSP	Program for the Prevention of Risk Associated with the Misuse of Psychoactive Substances in the Civil Aviation
PRE	Emergency Response Plan
PSOA	Airline Operator Safety Program
RADAR	Radio Detection And Ranging
RBAC	Brazilian Civil Aviation Regulation
REDEMET	Aeronautics Command Meteorology Network
SBEG	ICAO Location Designator – Eduardo Gomes Aerodrome, Manaus - AM
SBMN	ICAO Location Designator – Ponta Pelada Aerodrome, Manaus - AM
SC	Stratocumulus
SCT	Scattered (3 and 4 oktas)
SIC	Second in Command
SIGWX	Significant Weather
SN	Serial Number
SIPAER	Aeronautical Accident Investigation and Prevention System
SOP	Standard Operating Procedures
SPECI	Aviation Selected Special Weather Report
SWMW	ICAO Location Designator – Maués Aerodrome - AM
SWPI	ICAO Location Designator – Parintins Aerodrome - AM
TCU	Towering Cumulus
TPR	Aircraft Registration Category of Regular Public Transport
TSO	Time Since Overhaul
TSRA	Thunderstorm with Rain
TWR-EG	Control Tower - SBEG
UTC	Universal Time Coordinated
VFR	Visual Flight Rules

1. FACTUAL INFORMATION.

Aircraft	**Model:** 208B **Registration:** PT-MHC **Manufacturer:** Cessna Aircraft	**Operator:** Two Air Taxi Ltd.
Occurrence	**Date/time:** 16SEPT2019 - 1625 UTC **Location:** Eduardo Gomes Aerodrome (SBEG) **Lat.** 03°02'27"S **Long.** 060°04'00"W **Municipality – State:** Manaus – AM	**Type(s):** "[WSTRW] Windshear or Thunderstorm" **Subtype(s):** Nil

1.1 History of the flight.

The aircraft took off from the Eduardo Gomes Aerodrome (SBEG), Manaus - AM, to the Maués Aerodrome (SWMW) - AM, at about 1625 (UTC), in order to transport cargo and personnel, with two pilots and eight passengers on board.

Shortly after the take-off from threshold 29, the aircraft lost height and crashed in a wooded area to the left of the runway, 600 meters from threshold 11.

The aircraft had substantial damage.

One crewmember and three passengers suffered minor injuries, and one crewmember and five passengers suffered serious injuries.

1.2 Injuries to persons.

Injuries	Crew	Passengers	Others
Fatal	-	-	-
Serious	1	5	-
Minor	1	3	-
None	-	-	-

1.3 Damage to the aircraft.

The aircraft had substantial damage to the fuselage, wings, landing gear, horizontal stabilizer, and an elevator (Figures 1 and 2).

Figure 1 - View of the right front of the aircraft, after the impact and complete stop.

Figure 2 - View from the left side of the aircraft, after coming to a complete stop.

1.4 Other damage.

None.

1.5 Personnel information.

1.5.1 Crew's flight experience.

Flight Hours		
	PIC	SIC
Total	22.800:00	947:20
Total in the last 30 days	70:35	73:00
Total in the last 24 hours	00:00	00:00
In this type of aircraft	14.150:00	791:20
In this type in the last 30 days	70:35	73:00
In this type in the last 24 hours	00:00	00:00

N.B.: The data relating to the flown hours were obtained through the Two Air Taxi Ltd. Company.

1.5.2 Personnel training.

The PIC took the PPR course at the São Paulo Aeroclub - SP, in 1983.

The SIC took the PPR course at the *Escola Internacional de Aviação Civil* - PA, starting his training in 2013 and concluding it in 2016.

1.5.3 Category of licenses and validity of certificates.

The PIC had the PLA License and had valid MNTE and IFRA Ratings.

The SIC had the PCM License and had valid MNTE and IFRA Ratings.

1.5.4 Qualification and flight experience.

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

The PIC had experience in operations in the Amazon region and had been piloting the Caravan aircraft for 20 years.

1.5.5 Validity of medical certificate.

The pilots had valid CMAs.

1.6 Aircraft information.

The aircraft, serial number 208B0543, was manufactured by Cessna Aircraft in 1996 and was registered in the TPR Category.

The aircraft had a valid CA.

The aircraft maintenance technical records were updated.

The last inspections of the aircraft, the “DOC 06 and DOC 18” types, were carried out on 31AUG2019 by the maintenance organization Two Air Taxi Ltd., in Belém - PA, with 84 hours and 55 minutes flown after the inspection.

1.7 Meteorological information.

According to the SIGWX chart, which presented the weather forecast at 1800 (UTC), on 16SEPT2019, with projections in the period between 1500 and 2100 (UTC), there were three types of cloudiness: FEW clouds of the TCU type, with base at 3,000 ft and top at 24,000 ft; SCT clouds of the CU and SC types, with base at 2,000 ft and top at 8,000 ft; the presence of ISOL and EMBD Cumulonimbus in layers of other clouds, both with base at 3,000 ft and top above FL250; in addition to rain showers (Figures 3 and 4).

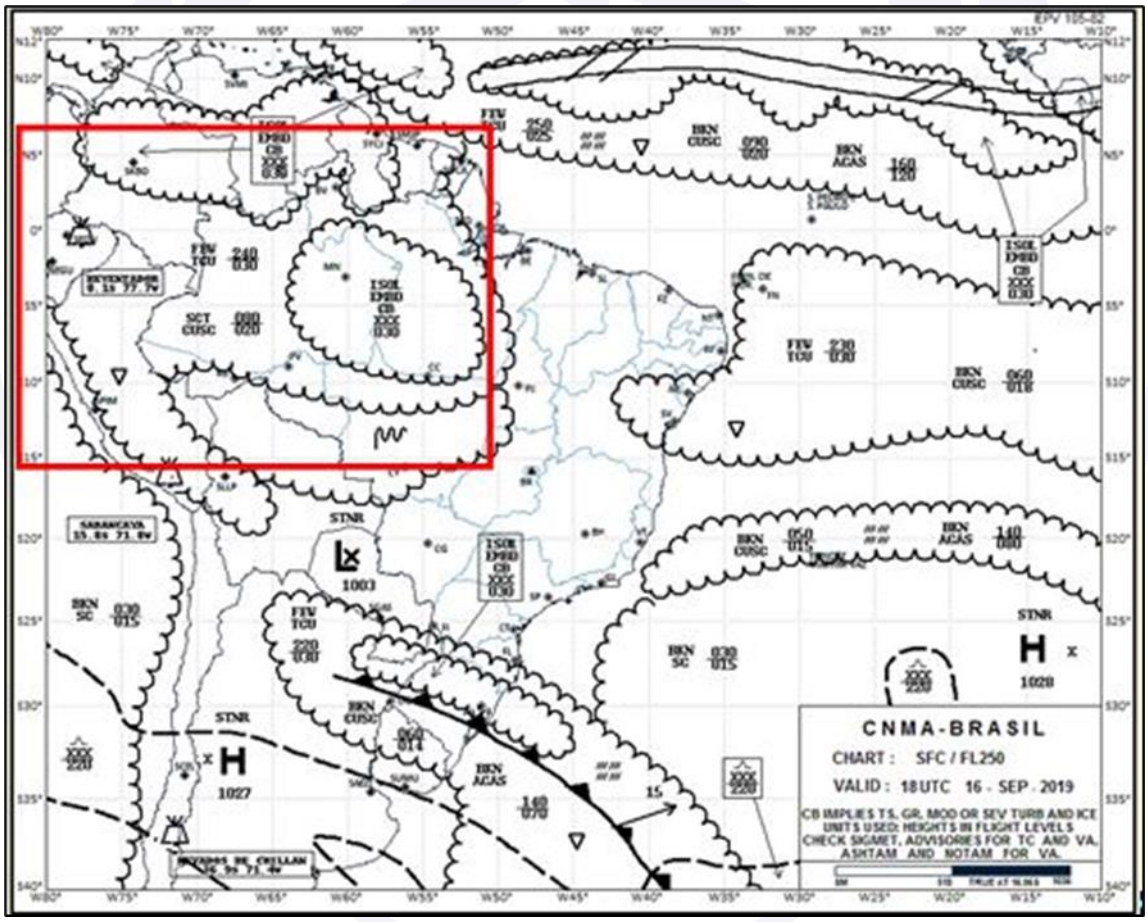


Figure 3 - SIGWX chart, referring to South America, taken from the REDEMET website, valid for 1800 (UTC), on 16SEPT2019. In detail, the area of the system that affected the region of Manaus at the time of the accident.

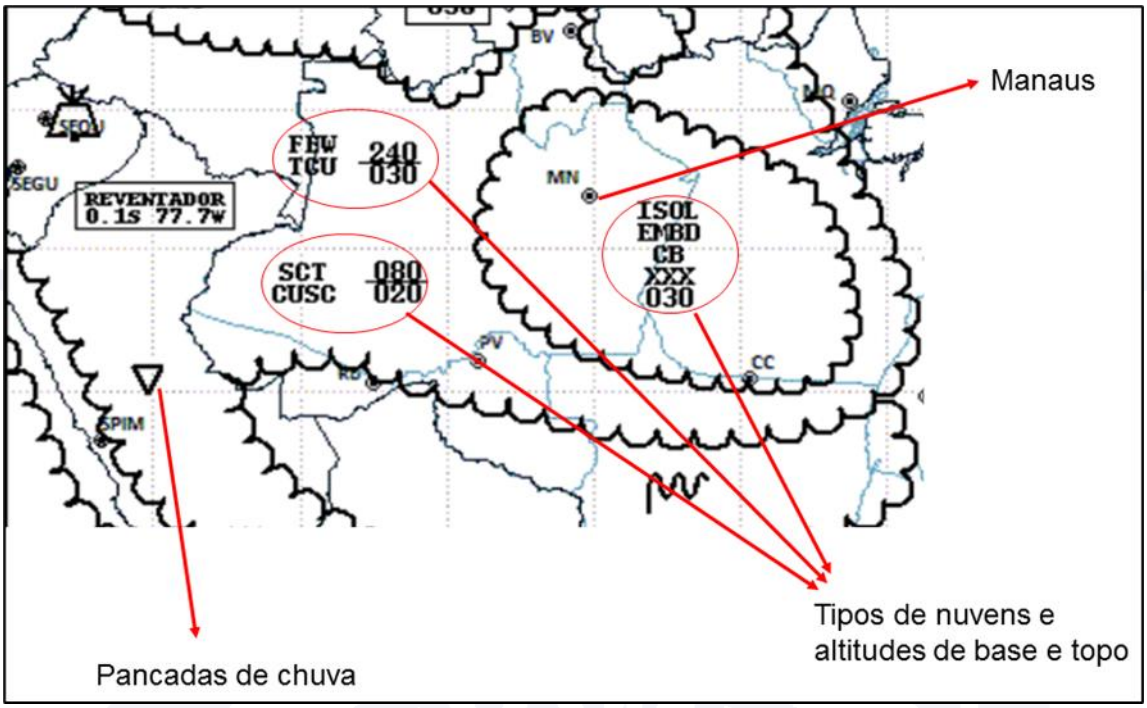


Figure 4 - Detail of the SIGWX chart, expanding the Northern region and identifying the symbols mentioned above.

With the enhanced images of the GOES 13, presented below, it was possible to identify the temperature of the top of the clouds (TCU and CB). The colder the cloud top, the more developed the storm, that is, the more severe (Figures 5, 6, 7, and 8).

In these images, it was observed that there was a large formation that intensified, that is, increased in size, and moved to the West of the Manaus region, identified with the purple color, in the period from 1600 to 1640 (UTC).

Also, according to the caption of the figure, it is observed that there was a large meteorological formation over the city of Manaus (the purple color that indicates the lowest temperature, approximately 80 degrees below zero), indicating a major storm over the city.

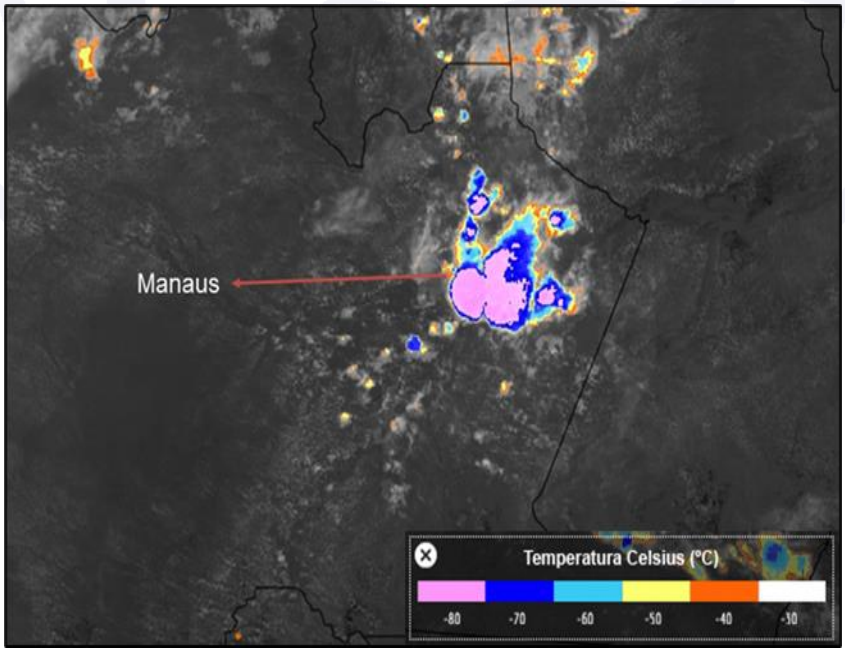


Figure 5 - Close-up view of the enhanced satellite image at 1600 (UTC). Manaus is the orange dot at the beginning of the red arrow. The formation shown in purple-pink was shifting to the left (West).

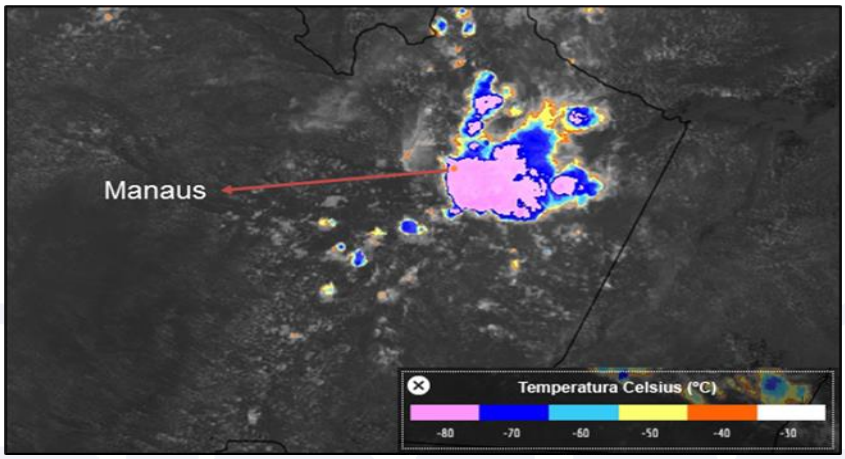


Figure 6 - Close-up view of the enhanced satellite image at 1620 (UTC). Manaus is the orange point at the beginning of the red arrow, already under the formation, which continued its displacement to the left (West).

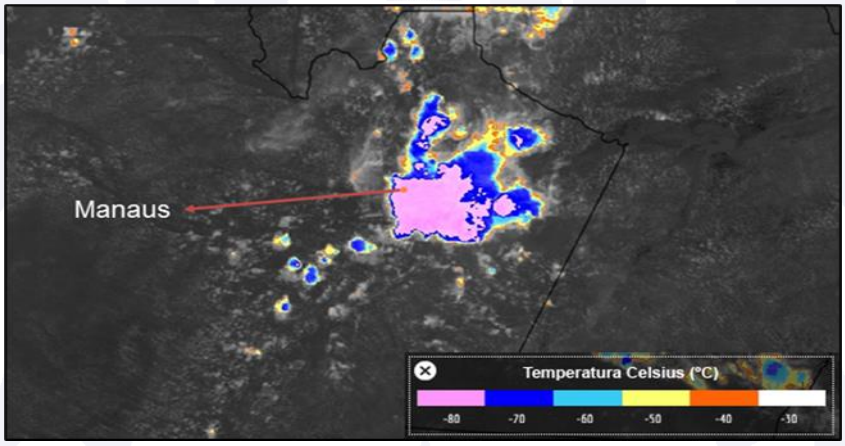


Figure 7 - Close-up view of the enhanced satellite image at 1630 (UTC). Manaus is the orange dot at the beginning of the red arrow below the formation, which continued to move to the left (West).

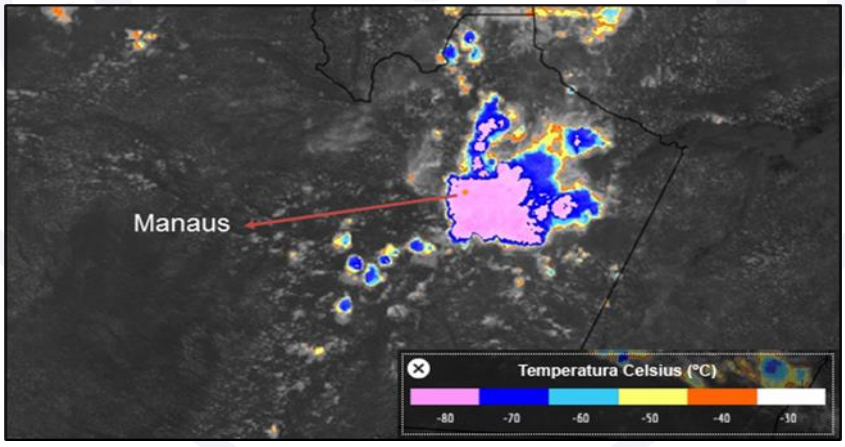


Figure 8 - Close-up view of the enhanced satellite image at 1640 (UTC). Manaus is the orange dot at the beginning of the red arrow below the formation, which continued to move to the left (West).

According to satellite images, it was found that, at 1630 (UTC), formations with CB and TCU characteristics intensified over the Manaus region, and then, at 1650 (UTC), they moved away from the city.

Another way used to check the meteorology at the time of the occurrence was through the image of the Max Cappi meteorological RADAR. This equipment provided the Cartesian projections in the vertical, North-South, and East-West directions, as well as the maximum

values of reflectivity (dBZ), precipitation rate and mean radial velocity or spectral width, observed during a volumetric scan. It could range from zero to one hundred millimeters per hour (mm/h).

The Max Cappi RADAR used a color scale according to the level of return (reflectivity), as shown in Figure 9 below:

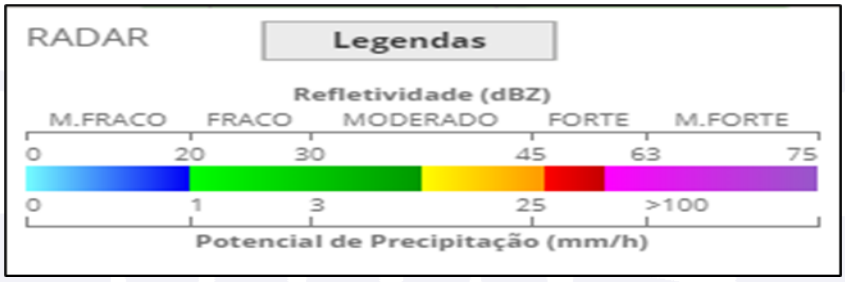


Figure 9 - Captions used in Max Cappi RADAR images.

ÍNDICE	CARACTERÍSTICAS
Menor que 15 dBZ	Traços de precipitação.
De 15 a 25 dBZ	Precipitação muito leve.
De 26 a 37 dBZ	Precipitação leve (3 mm/h ou 0,5 mm/10min). Associa-se a nebulosidade com predominância estratiforme para campos de média a grande extensão (>40 km).
De 38 a 42 dBZ	Precipitação moderada (10 mm/h ou 1,6 mm/10min). Intensificação de processos convectivos embutidos, muitas vezes, em camadas.
De 43 a 48 dBZ	Precipitação forte (30 mm/h ou 5 mm/10min). Associa-se a nebulosidade com predominância cumuliforme e convecção profunda: TCU e Cb (tempestades pouco intensas).

Figure 10 - Explanatory table of reflectivity levels, type of cloud, and precipitation present in the Max Cappi RADAR images.

The Max Cappi RADAR was operated by the DTCEA-MN, located at the Ponta Pelada Aerodrome (SBMN), Manaus - AM, and recorded the image sequences below, showing the potential for precipitation over SBEG.

It was found that, at 1620 (UTC), there was a greater intensity (red return of the RADAR) indicating heavy precipitation, with the possibility of storms, lightning, and severe turbulence (Figures 11 and 12).

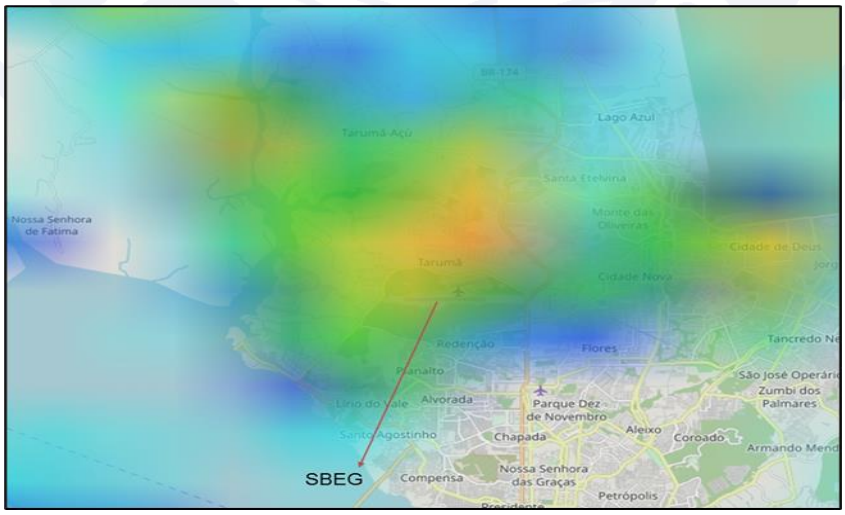


Figure 11 - Close-up image of the meteorological RADAR at 1620 (UTC). The beginning of the red color is observed, due to the existing formations in the vicinity of SBEG, indicating strong reflectivity and precipitation.

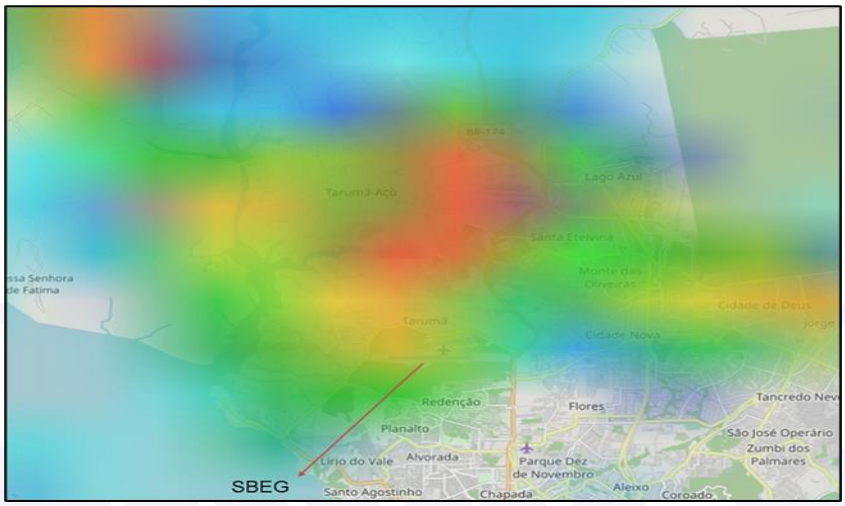


Figure 12 - Close-up image of the meteorological RADAR at 1625 (UTC). The meteorological formation existing in the vicinity of SBEG is observed, with an intensified and more comprehensive red color, indicating strong reflectivity and precipitation.

According to information available on the REDEMET, the conditions in SBEG were as follows (Figure 13):

Localidade	Tipo	Data/Hora	Mensagem
SBEG	Aviso Aeródromo	16/09/2019 15:00	SBEG SBEG AD WRNG 2 VALID 161600/162000 TS SFC WSPD 15KT MAX 30 FCST INTSF=
SBEG	METAR	16/09/2019 15:00	METAR SBEG 161500Z 24006KT 9999 SCT020 FEW025TCU 32/23 Q1012=
SBEG	Aviso Aeródromo	16/09/2019 16:00	SBEG SBMN AD WRNG 3 VALID 161655/161910 TS WSPD 20KT MAX 35 FCST INTSF=
SBEG	METAR	16/09/2019 16:00	METAR SBEG 161600Z 21009KT 8000 -SHRA SCT020 FEW025TCU SCT100 31/24 Q1011=
SBEG	SPECI	16/09/2019 16:00	**SPECI SBEG 161606Z 14014KT 2000 SHRA SCT020 FEW025TCU SCT100 25/19 Q1012=**
SBEG	SPECI	16/09/2019 16:00	**SPECI SBEG 161624Z 27016KT 3000 TSRA BKN014 FEW025CB SCT100 22/19 Q1012=**
SBEG	SPECI	16/09/2019 16:00	**SPECI SBEG 161634Z 27017G46KT 4000 1500W TSRA BKN012 FEW025CB SCT100 20/18 Q1011=**
SBEG	Aviso Aeródromo	16/09/2019 17:00	SBEG SBPV AD WRNG 4 VALID 161800/162000 TS SFC WSPD 15KT MAX 30 FCST INTSF=
SBEG	METAR	16/09/2019 17:00	METAR SBEG 161700Z 31008KT 4000 -TSRA SCT010 BKN020 FEW025CB 21/20 Q1011 RETSRA=

Figure 13 - Meteorological information from SBEG between 1500 (UTC) and 1700 (UTC). Data extracted from the REDEMET website.

It was found that, at 1500 (UTC) and 1600 (UTC), two Aerodrome warnings were issued, one for each hour. This message consisted of concise information about the forecast of adverse weather conditions that could affect the safety of aircraft, including those on the ground (parked), Aerodrome facilities, and services.

The first one, valid from 1600 (UTC) to 2000 (UTC), predicted thunderstorms and a surface wind of 15 kt, and a maximum of 30 kt. The second one, valid from 1655 (UTC) to 1910 (UTC), predicted thunderstorms and surface wind of 20 kt, maximum of 35 kt, with a forecast of intensification during the period (INTSF).

This prediction was confirmed with the issuance of SPECI, used for the complete description of meteorological conditions when one or more significant variations occur between the intervals of regular observations, which are made every hour.

Three SPECI messages were issued, respectively at 1606 (UTC), 1624 (UTC), and 1634 (UTC). Such messages reported the degradation of visibility in the West sector, which reached 1,500 meters, as well as the reduction of the height of the cloud layer base from

1,400 ft to 1,200 ft. The wind increased from 14 kt to 17 kt and, in the last message, gusts of up to 46 kt were observed.

Furthermore, the presence of the Cumulonimbus cloud may be associated with meteorological phenomena such as Windshear, Tornados, Downburst, and Microburst.

Windshear can occur at all flight levels, however, it is particularly dangerous at lower levels, during the approach, landing, takeoff, and initial climb phases, due to the low height and reduced speed of the aircraft (Figure 14).

Windshear can cause different effects on aircraft such as turbulence, sudden increase or decrease in the indicated speed, and sudden and dangerous variations in the vertical speed, altimeter, and angle of attack indicators.

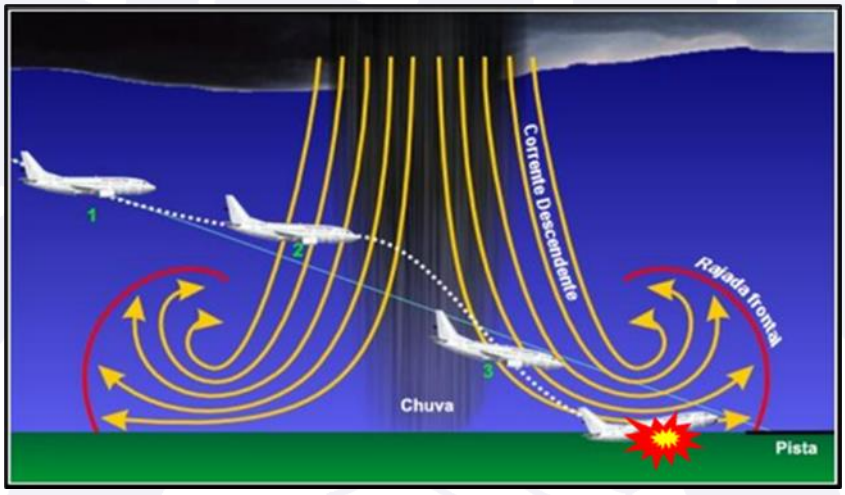


Figure 14 - Explanatory photo of Windshear and its consequences on aircraft. The yellow arrows indicate the direction of the winds.

The Downburst is a strong downdraft of air that circulates throughout the base of the Cumulonimbus cloud (Figure 15).

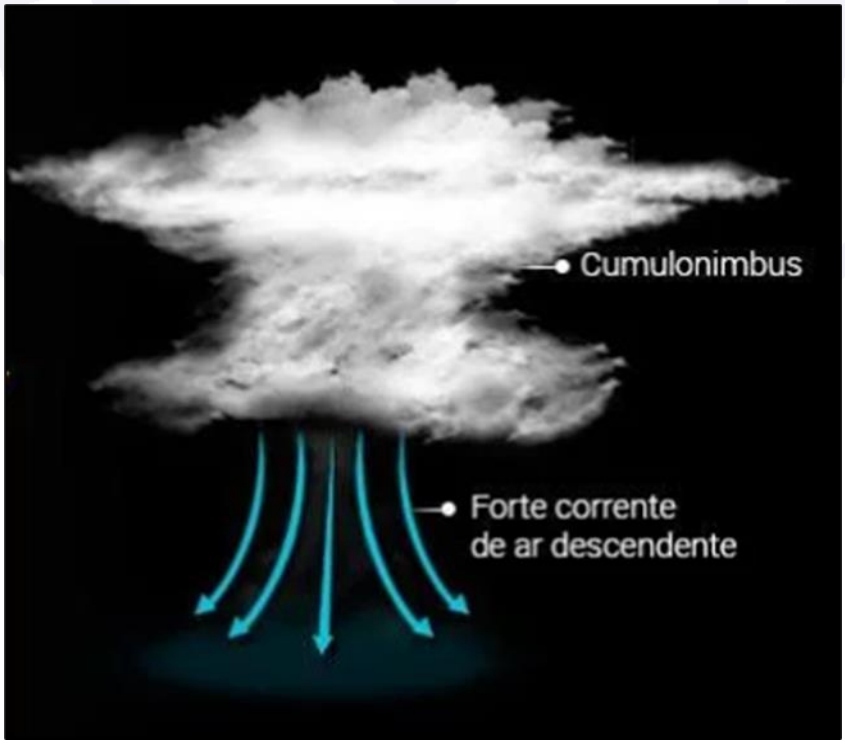


Figure 15 - Downburst explanatory photo.

A microburst is a downdraft of air concentrated in a smaller area of the base of the Cumulonimbus cloud (Figure 16).

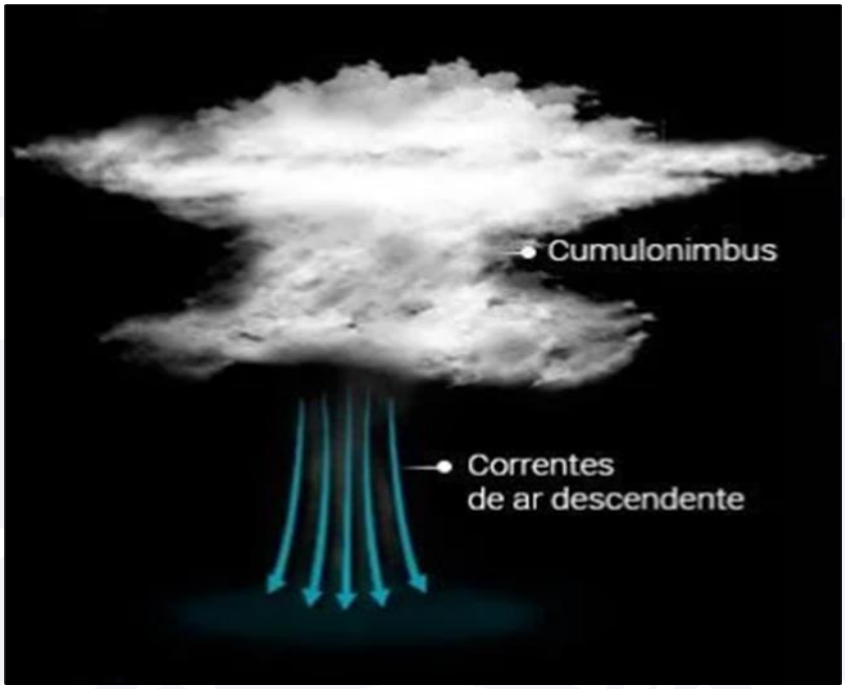


Figure 16 - Explanatory photo of Microburst.

The difference between Downburst and Microburst is the size of the affected area below the cloud. Microburst, being smaller, impacts an area of up to 4 km².

1.8 Aids to navigation.

All navigation and landing aids were operating normally at the time of the occurrence.

1.9 Communications.

According to the transcripts of the communication audios between the PT-MHC and the control agencies, it was found that the crewmembers kept radio contact with the SBEG TWR-EG and with the APP-MN, and no technical abnormality of communication equipment was found during the flight.

To complement the contact information, a transcript of the most relevant moments of the conversation between the crew and the control agencies will be presented in chronological order, in UTC.

At 15:35:42, the crewmembers requested authorization of the flight plan under VFR for Maués. At 15:42:19, authorization was given as requested in the flight plan.

At 16:09:06, the Control Tower called the crew to inform them that the Aerodrome was operating under IFR and that the visibility was 3,000 m.

At 16:11:33, already authorized to start the engines, the crewmembers informed that it was “IFR approved” and requested coordination so that the departure was IFR up to the Manaus Terminal limit. After that point, the VFR plan would be followed.

At 16:13:49, the crew reported that they were ready for the activation. The Tower responded in the sequence that the activation was “at the crew`s risk”.

At 16:17:20, the Tower authorized the taxi to the holding point on runway 11.

At 16:19:13, the Tower issued a new authorization, restricting the taxi to the “cemetery abeam”, which was before taxiway B.

At 16:21:49, the Tower informed that the runway had changed and that the take-off would be from the threshold 29.

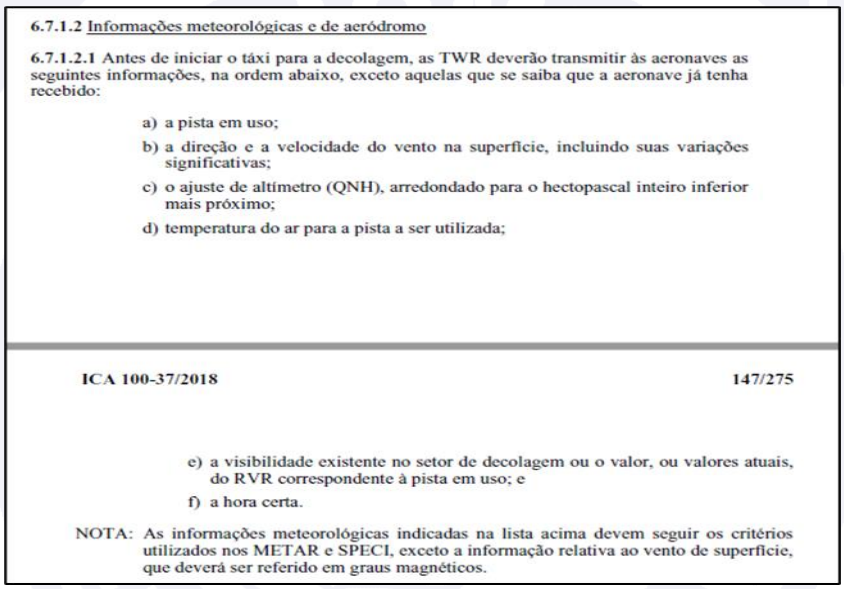
At 16:22:15, the Tower authorized the taxi to the holding point on runway 29.

At 16:24:19, the Tower authorized the aircraft to align and takeoff from runway 29. It reported a wind with a direction of 300º and an intensity of 20 kt and an altimeter setting of 1011 HPa.

At 16:25:37, the crew reported that it had already taken off and was crossing 500 feet.

During the preparations for the takeoff of the PT-MHC, the APP-MN had two aircraft on approach to SBEG. An Airbus A320 aircraft was performing a holding orbit due to adverse weather conditions and, after a few minutes, proceeded to the alternate Aerodrome without attempting an approach to SBEG. The other aircraft, an ATR-42, performed a go-around procedure during the final approach of the ILS procedure to runway 11 and reported rain with turbulence and strong wind. After a few minutes on hold, it also proceeded to the alternative.

According to the ICA 100-37/2018 - “Air Traffic Services”, item 6.7.1.2 provided for the following (Figure 17):



6.7.1.2 Informações meteorológicas e de aeródromo

6.7.1.2.1 Antes de iniciar o táxi para a decolagem, as TWR deverão transmitir às aeronaves as seguintes informações, na ordem abaixo, exceto aquelas que se saiba que a aeronave já tenha recebido:

a) a pista em uso;
b) a direção e a velocidade do vento na superfície, incluindo suas variações significativas;
c) o ajuste de altímetro (QNH), arredondado para o hectopascal inteiro inferior mais próximo;
d) temperatura do ar para a pista a ser utilizada;

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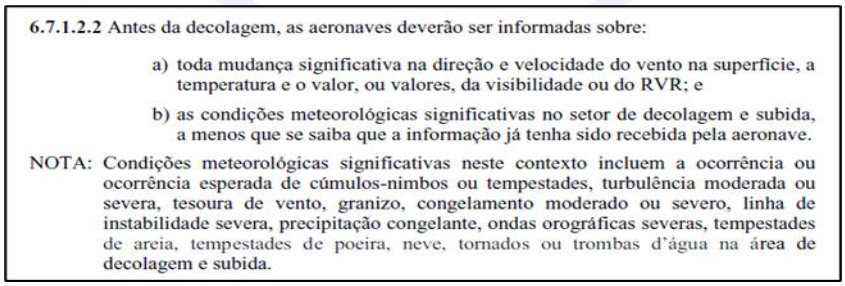
e) a visibilidade existente no setor de decolagem ou o valor, ou valores atuais, do RVR correspondente à pista em uso; e
f) a hora certa.

NOTA: As informações meteorológicas indicadas na lista acima devem seguir os critérios utilizados nos METAR e SPECI, exceto a informação relativa ao vento de superfície, que deverá ser referido em graus magnéticos.

Figure 17 - Item 6.7.1.2 of the ICA 100-37/2018, referring to meteorological and Aerodrome information that should be passed by the Control Tower to the aircraft, before starting the taxi.

During the taxi, only two of this information (Figure 17) were passed to the PT-MHC: the visibility of 3,000 m and the runway in use.

Item 6.7.1.2.2 of the ICA prevised to inform the aircraft of significant meteorological changes (Figure 18).



6.7.1.2.2 Antes da decolagem, as aeronaves deverão ser informadas sobre:

a) toda mudança significativa na direção e velocidade do vento na superfície, a temperatura e o valor, ou valores, da visibilidade ou do RVR; e
b) as condições meteorológicas significativas no setor de decolagem e subida, a menos que se saiba que a informação já tenha sido recebida pela aeronave.

NOTA: Condições meteorológicas significativas neste contexto incluem a ocorrência ou ocorrência esperada de cúmulos-nimbos ou tempestades, turbulência moderada ou severa, tesoura de vento, granizo, congelamento moderado ou severo, linha de instabilidade severa, precipitação congelante, ondas orográficas severas, tempestades de areia, tempestades de poeira, neve, tornados ou trombas d’água na área de decolagem e subida.

Figure 18 - Item 6.7.1.2.2 of ICA 100-37/2018, referring to the information that should be passed by the Control Tower to the aircraft, before the take-off.

These changes or significant weather conditions were also not reported to the crew.

In addition, sub-item 6.19.5, of item 6.19 - “Aerodrome Meteorological Minimums”, provided that the Control Towers were accredited to assess meteorological conditions in the approach and take-off sectors (Figure 19).

6.19.5 A TWR é órgão credenciado para avaliar as condições meteorológicas nos setores de aproximação e de decolagem.

Figure 19 - Sub-item 6.19.5, of item 6.19 of the ICA 100-37/2018, informing about TWR accreditation.

Shortly after the take-off, the crew made the initial call on the APP-MN frequency, and, from that moment on, the aircraft no longer responded to messages.

The TWR-EG and the APP-MN did not occupy the same room. Despite this, they had direct contact by telephone, in order to facilitate coordination between them.

According to items 10.5.5.3.1 and 10.5.5.3.2, of the ICA 100-37/2018 (Figure 20), the APP was not required to inform the Tower of reports of significant formations in the Terminal area.

10.5.5.3.1 A TWR manterá o APP permanentemente informado de dados pertinentes ao tráfego aéreo controlado, tais como:

a) horas de pouso e de decolagem;

b) indicação de que a primeira aeronave da sequência de aproximação está em comunicação com a TWR e à vista dessa e que há razoável certeza de que ela completará o pouso;

c) toda informação disponível relacionada com as aeronaves atrasadas ou com aquelas de que não se tem notícias; e

d) informação referente às aeronaves que constituam tráfego essencial para as aeronaves sob controle do APP.

10.5.5.3.2 O APP manterá a TWR permanentemente informada de dados pertinentes ao trafego aéreo controlado, tais como:

a) hora prevista e nível proposto de chegada das aeronaves sobre o aeródromo, com 15 minutos de antecedência, pelo menos, da hora estimada de pouso, quando o tempo de voo da origem ao destino o permitir;

NOTA: Para o caso de aeródromos afastados por menos de 15 minutos de voo, esse intervalo será o maior possível, visando permitir a prestação adequada do Serviço de Tráfego Aéreo à aeronave em questão.

b) indicação de ter autorizado uma aeronave a estabelecer contato com a TWR e que tal órgão assumirá o controle; e

c) atrasos previstos para as decolagens devido a congestionamento de tráfego.

Figure 20 - Items 10.5.5.3.1 and 10.5.5.3.2 of the ICA 100-37/2018, referring to the TWR information for the APP and vice versa.

In an interview, it was found that the meteorological service sought to inform the control agencies of all changes that were occurring due to local atmospheric instability (Figure 21), acting by item 10.7 of the ICA 100-37/2018.

10.7 COORDENAÇÃO ENTRE ÓRGÃOS ATS E O SERVIÇO DE METEOROLOGIA

Os órgãos ATS deverão manter estreita coordenação com o serviço de meteorologia local, tendo em vista:

a) prováveis condições do tempo que possam acarretar riscos à navegação ou suspensão de operação de um ou mais aeródromos sob sua jurisdição; e

b) prováveis melhorias nas condições meteorológicas que provocaram uma suspensão das operações, a fim de possibilitar uma melhor coordenação de tráfego aéreo.

Figure 21 - Item 10.7 of the ICA 100-37/2018, referring to information between the meteorology service and the control agencies.

It is worth mentioning that the APP-MN and the TWR-EG used different radio frequencies to communicate with the aircraft, that is, the aircraft tuned to the Tower did not listen to the Control transmissions.

1.10 Aerodrome information.

The Aerodrome was public, managed by the INFRAERO, and operated under VFR and IFR, day and night.

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

1.11 Flight recorders.

Neither required nor installed.

1.12 Wreckage and impact information.

The impact occurred 600m from the runway 11 threshold of SBEG, with evidence of previous impacts on the local vegetation. The distribution of the wreckage was of the concentrated type (Figure 22).

The first impact occurred in a pitch-up attitude. The horizontal stabilizer (right side) collided with a tree branch and the elevator on that side came off. The second impact occurred against another tree, causing the separation of the meteorological RADAR, located on the right wing, and a part of the horizontal stabilizer (left side).

After the second impact, the aircraft stopped at heading 240°, approximately, 30º to the left concerning the trajectory of the fall, and at 50º about the take-off axis (290º).

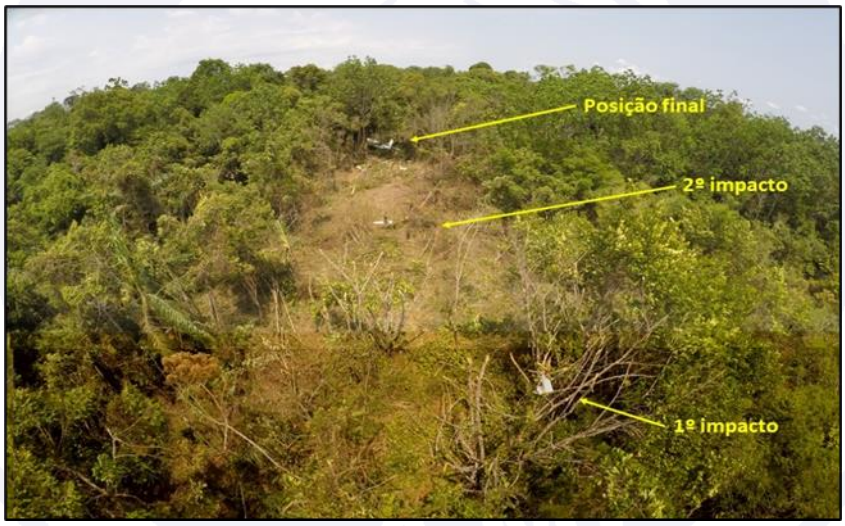


Figure 22 - Aerial view of the accident site. The details show the points of impact and the final position of the aircraft.

There was a fire started after the total stop, which was contained by the action of two occupants.

The landing gear, of the fixed type, was twisted upwards. According to the crew's report, the flaps were lowered to the take-off position, however, due to the impacts, it was not possible to verify the exact position they were in, and it was not possible to specify the position of the trim tabs (Figures 23, 24 and 25).

Figure 23 - Close-up view of the aircraft after coming to a complete stop. The yellow arrows indicate the position of the left landing gear, the broken elevator trim, and the part of the left wing that has bent up from the aircraft.

Figure 24 - Close-up view of the right side and top of the aircraft. In the details, the position of the right-wing, the left-wing flap, and a blade of the propeller assembly.

Figure 25 - Close-up view of the right side of the aircraft, near the passengers` door. In the details, the position of the right-wing and the final position of the propeller assembly.

The propeller assembly was found next to the passengers` door. The left-wing flap was above the roof of the aircraft. The right-wing was twisted back and down.

The set of levers was found with the power, propeller, and fuel levers forward, normal position for take-off, however, it is possible that they moved on the impact. In addition, the emergency power lever (EPL) was at half-stroke. However, according to the commander's report, this control was not activated. (Figure 26).

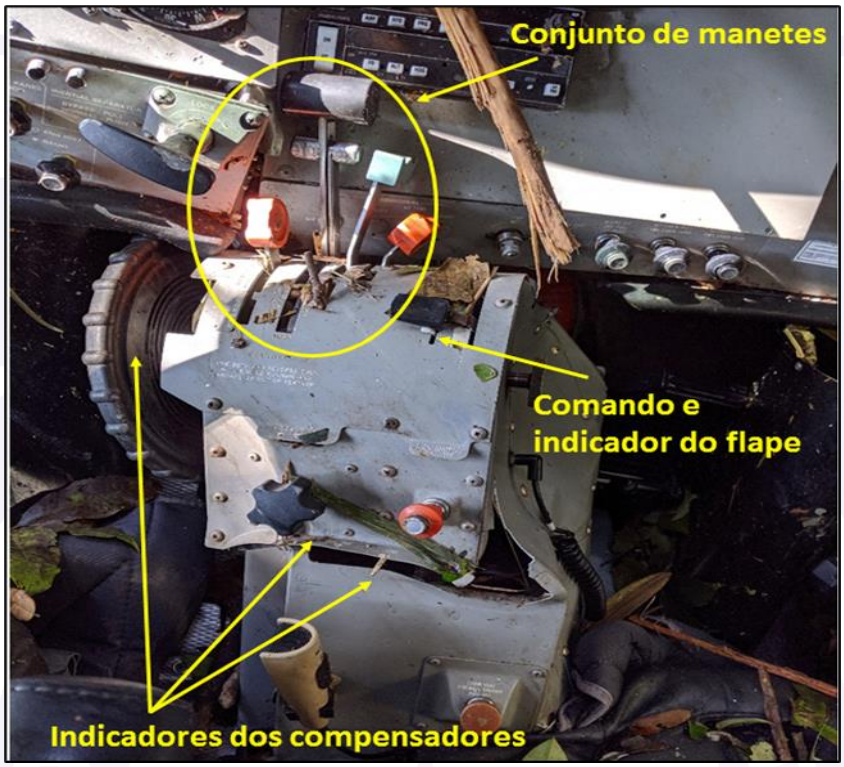


Figure 26 - Close-up view of the aircraft's central panel. In the details, the positions of the levers, the indicators of the tabs, the command, and the indicator of the flap.

The horizontal stabilizer was missing the right elevator. The vertical stabilizer and the rudder were missing their upper parts (Figure 27).

Figure 27 - Close-up view of the empennage.

The position of the fuel selectors was modified by the impact, and it was not possible to conclude which positions they were in before the accident (Figure 28).

Figure 28 - Close-up view of the fuel selector panel. The selectors were moved by the impact.

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's performance.

The PIC did not perform the toxicological examination, as he was hospitalized in a coma. The examination carried out at the SIC ruled out evidence of psychoactive substances.

1.13.2 Ergonomic information.

Nil.

1.13.3 Psychological aspects.

Reports obtained during the investigation indicated that the PIC felt pressured to perform the take-off. This pressure would be related to the fulfillment of the flight schedule and the need to maintain the scheduled times. Furthermore, it was informed that, within the planning of that flight, there was not an adequate margin of time to absorb any delays. Thus, if the take-off did not take place at that moment, the flight would possibly not be able to return to Manaus on the same day.

It was raining and windy from the moment the passengers boarded the aircraft. A passenger reported having asked the pilots if they would take off in that rain and one of them replied not to worry because the aircraft was safe to operate in those conditions. It was also highlighted that the rains in Manaus were short-lived.

One of the duties of the airline's dispatcher was to send the take-off confirmation to the CCO, which was located in Jundiaí - SP. Therefore, he used to follow the takeoffs of the operator's flights and reported that, unlike the other flights, that day, he could not see the aircraft taking off due to the intense fog.

1.14 Fire.

A fire started on the right side of the engine, which was contained by the SIC using the aircraft's portable fire extinguisher (Figure 29). The origin of the fire was undetermined.

Figure 29 - Close-up view of the right part of the aircraft engine. The yellow arrow shows the presence of white powder where the fire extinguisher was used.

1.15 Survival aspects.

According to reports obtained, the PIC always asked the SIC to “Speech to the passengers” before starting the engine. He did not usually use the harnesses, justifying that it bothered him and, on the flight of the accident, the “Speech to the passengers” was not made by him or by the SIC.

The SIC abandoned the aircraft through his door, as it was broken in the fall. Subsequently, a passenger exited through an opening in the fuselage, caused by the impact at the location of the pilot's door.

Then, these two helped to remove six passengers who were loose and who were able to move. The other two passengers were taken out by the rescue team, as they were trapped in the wreckage. The PIC got stuck in his position (left seat) and was the last to be removed.

Supporting the rescue were: a FAB helicopter, firefighters, and the airport emergency team.

The passenger and cargo doors were obstructed by the wreckage, and it was not possible to use them for the abandonment of the aircraft.

1.16 Tests and research.

The Pratt & Whitney engine that powered the aircraft, model PT6A-114A, Serial Number (SN) PC-E17048, manufactured in May 1985, had a total of 24,102 hours and 40 minutes and a TSO of 1,784 hours and 10 minutes.

According to the analysis of the DCTA, it was found that, by the internal signatures, the engine had a normal operation with power development at the moment of impact.

1.17 Organizational and management information.

The company Two Air Taxi Ltd. was authorized to carry out commercial public air transport operations, according to the RBAC 135. It was granted by the ANAC, through

Decision No. 14, of 25JAN2018, to explore scheduled passenger and cargo air transport services.

The operational headquarters, as well as the main base of operations, was located in Jundiaí - SP, where the administration personnel required by the regulations in force at the time of the accident were located, namely: Responsible Manager, GSO, Operations Director, Chief Pilot, and Maintenance Director. During a visit to the company, it was found that there was also a Quality Manager who worked in the operational safety, maintenance, and operations processes.

In Jundiaí, there was also the CCO, which operated 24 hours a day in three shifts of 8 hours each.

To manage the airworthiness of its aircraft, the company had a system, with the commercial name of CAVOK, which was used by the crew and also by the employees involved directly and indirectly with the operational activities.

The company's fleet consisted of 17 Cessna 208 and 208B model aircraft distributed throughout Brazil. At the base in Manaus, there was only one aircraft, and the flights were scheduled to leave and return on the same day.

It was found that the company complied with all the requirements regarding the maintenance of the PT-MHC.

In addition, the MGE was composed of the following manuals: MGO, MGM, MGSO, PrTrnOp, MEL, Checklist (one for each cockpit), Passenger Instruction Card, MAP, ERP, CRM, PSOA, SOP, PPSP, and the PGRF.

Normally, each crewmember flew 60h/month. The roster was sent every 30th of the previous month. Daily, at 1730 (local time), the next day's flights were coordinated. Thus, it was possible to carry out the planning and changes that might be necessary.

To maintain the technical proficiency of its crew, the company had a flight simulator, although such equipment was not required for the aircraft's operating category.

There were two accredited examiners, in Jundiaí and in Porto Alegre, all with the Civil Aviation Inspector course to carry out the pilots' checks.

The crewmembers did not brief the passengers on emergency procedures, despite it being provided for in the company's MGO as mandatory in item 6.6.2 - Verbal instructions to passengers, "Speech to the passengers", which was described in Annex 5 of this Manual.

In the MGO, in item 12.5 - Survival and emergency equipment, it was stated that the aircraft should have a jungle kit for the operation in the region of this flight, however, this kit was not found in the occurrence.

The company provided theoretical and practical jungle survival training.

1.18 Operational information.

It was the regular flight OWT5582 carried out by Two Air Taxi Ltd. The aircraft would take the SBEG - SWMW - Parintins Aerodrome (SWPI), AM - SBEG sections.

The first flight plan submitted to Maués - AM, was VFR, with the taxi start time scheduled for 1610 (UTC).

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

In an interview, the pilots said that they reported for the flight at 1530 (UTC) and that they carried out all the procedures foreseen before departure, including checking the weather reports.

The boarding of passengers took place in light rain.

Thus, after authorization from the TWR-EG, the taxi procedure, and the take-off were carried out. It should be noted that, initially, the visual flight was authorized, but when the PT-MHC reported being ready for activation, it was informed that SBEG was operating IFR.

With that, the crew requested the change of the flight plan so that the take-off was in IFR conditions. At the holding point, the aircraft received the wind intensity information as being 20 kt.

During the taxi, while the aircraft was waiting for the runway change, near taxiway B, the rain was advancing towards the threshold of runway 11, that is, moving to the west. When the PT-MHC arrived at threshold 29, the rain was already intense. It was not possible to view the take-off from the security camera footage of the airport administrator.

In section 9.20 - Storm avoidance in flight and Windshear, of the SOP, revision 4, from 03JUL2019, it was foreseen that the pilot should avoid landings and takeoffs when there was reported CB activity up to 5 NM from the Aerodrome, especially if on the take-off course.

Also, if you found Windshear, after the rotation speed or on the initial climb, the maximum available power should be used.

According to MGO's revision 18 from 07AUG2018, in item 11.17 - Adverse weather conditions or other dangerous situations, the company prohibited take-off if there were no safe atmospheric conditions for the flight to take place.

The take-off took place amid heavy rain and poor visibility. It was reported in an interview that the PIC asked the SIC to accompany the instruments while he “flew the aircraft”.

Upon communication with the Control Tower that the aircraft had taken off, the EGPWS issued audible ground proximity alerts.

In an interview, the crew reported not having activated the emergency throttle and confirmed that they would not use it in that case, as it should only be used in the event of a fuel pump failure. They also reported that the PIC was flying the aircraft while the SIC was checking the instruments, especially the speed indicator.

When reporting the accident, the SIC mentioned that visibility, due to cloudiness, was limited at the time of take-off. He also informed that, shortly after the take-off, suddenly, the plane began to face severe turbulence, swaying very horizontally. Afterward, he felt an impact and was only able to protect himself. There was, therefore, no operational reaction.

The company's Operational Training Program was well established and active. It was composed of the following elements: classroom and distance lectures, operational demonstration, and experimental demonstration.

In addition, the company had the AATD - Redbird CRV - S/V, which was a flight simulator used in all phases of pilot training (initial, periodic, level up, and instructor).

In this training, procedures were foreseen that allowed the pilot to recognize and effectively respond to a Windshear situation, using the EGPWS and evasive maneuver to avoid CFIT. It is noteworthy that the first rule for these situations was not to enter areas where this phenomenon was expected to occur. The commander did a periodic training on September 11 (annual frequency), however, the SIC had not yet carried it out.

There was a NOTAM (Figure 31) about works on the Aerodrome runway. This restricted operating hours. On the day of the occurrence, the runway would be closed between 2005 and 0259 (UTC).

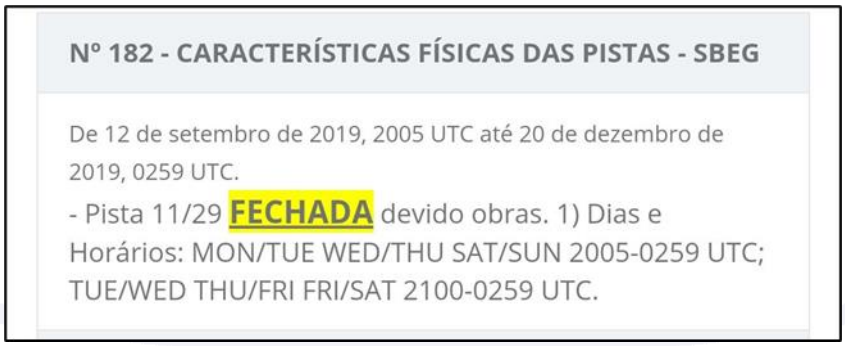


Figure 31 - NOTAM information valid for the day of the accident, with the times when the runway would be closed.

To calculate the aircraft time of landing on SBEG, after the completion of the planned flights, the beginning of the taxi at 1610 (UTC) was considered, according to the flight plan, and the take-off at 1620 (UTC). The take-off and landing times, on the Manaus - Maués - Parintins - Manaus route, are shown in Figure 32, plus a 30-minute ground time in each location, a time reported informally by the operator. It is noted that, according to the planning carried out by the company, it would not be possible to complete the route and return to Manaus before the closing of the runway.

TAKE-OFF	TIME	LANDING	TIME
SBEG	16:20Z	SWMW	17:25Z
SWMW	17:55Z	SWPI	18:25Z
SWPI	18:55Z	SBEG	20:10Z

Figure 32 - Estimated planned take-off and landing times of the intended route, considering a ground time of 30 minutes.

1.19 Additional information.

Nil.

1.20 Useful or effective investigation techniques.

Nil.

2. ANALYSIS.

It was a regular flight carried out by Two Air Taxi Ltd.

Analyzing the data collected, it was possible to observe that there were two significant changes between the initial contact of the crewmembers with the control unit until their authorization to takeoff: the modification of the departure from VFR to IFR; and the runway in use, from 11 to 29.

Before and during the taxi, the TWR-EG informed the PT-MHC about the visibility of 3,000 m and the runway in use.

No significant weather changes or conditions were reported before the take-off. This information could have helped the PIC's decision-making on the pertinence of taking off at that moment.

According to available meteorological information, the city of Manaus - AM, more specifically the SBEG area, was under conditions of atmospheric instability. There was the presence of several types of clouds, among them CB and rain formations that moved to the West and intensified.

Under these conditions, the taxi was initially authorized for runway 11, however, this authorization was modified, as the runway in use was changed, and the PT-MHC was instructed to taxi to runway 29.

Ten minutes before the take-off, an aircraft from another company took off on the approach to runway 11. Meanwhile, another was on hold, waiting for conditions to improve at SBEG. The two continued to their respective alternate Aerodromes due to weather conditions, a few minutes before the PT-MHC took off.

Although the APP was not responsible for informing the Tower about reports of significant formations in the Terminal area, the transmission of this information to the TWR, and from it to the aircraft, could assist the PIC in assessing the risks involved in the operation under these circumstances.

The Aerodrome Warnings, METARs, and SPECIs issued after 1600 (UTC) showed the rapid degradation of weather conditions. Considering the chronology of the flight, observed in the transcripts of communications, it is possible that the crewmembers were not aware of this evolution.

The heavy rain and reduced visibility were clear in the airport administrator's camera footage. Wind gusts were recorded on the runway measurement equipment and presented in the aforementioned messages. This associated information suggests the occurrence of Windshear.

At the time of takeoff, information from the SBEG`s SPECI from 1624 (UTC), which served as a basis for meteorological reports, reported visibility of 3,000 m, thunderstorms with rain (TSRA), presence of CB based on 2,500 ft, ceiling of 1,400 ft and wind speed of 16 kt.

According to the SOP, the pilot should avoid landings and take-offs when there were CBs in activity at distances of up to 5 NM from the Aerodrome, especially if the formation was on the take-off course. This information was reinforced in the MGO, which prohibited take-off in the presence of instabilities and even if there were no safe atmospheric conditions for the flight.

However, despite these regulations, the crew took off under adverse weather conditions.

The PIC had been flying for more than thirty-five years and had a PLA License, having accumulated 22,800 total flight hours, of which 14,150 hours were on 208 series aircraft. With this data, it was found that the pilot was experienced in the aircraft and operations in the region.

Five days before the accident, the PIC conducted flight simulator training for Windshear situations. Although he was trained in a simulator, it was considered that this training may not have been sufficient to develop the necessary skills to avoid and manage those conditions. As per training, the first rule for these situations was not to enter areas where this phenomenon was expected to occur, which could have been done if the take-off had been canceled under those conditions.

When evaluating the history of the crew and the organizational environment in which they were involved, it is inferred that familiarity with the region and experience in the aircraft may have induced the PIC to overestimate his mastery of the task in order to present a mistaken perception of the real risks involved in the presented scenario, thus influencing his decision to take off in those meteorological conditions.

The reports indicated that the PIC, at that time, felt pressured to perform the take-off. Also, according to the interviews, this pressure would be related to the fulfillment of the flight schedule and the need to comply with the scheduled times. In addition, it was informed that,

within the planning of that flight, there was no margin of time to absorb any delays. If the take-off did not take place at that time, the flight would possibly not be able to return to Manaus on the same day.

The operator scheduled flights to depart and return on the same day. Due to this condition, the company tended to value the fulfillment of the legs which, at times, could imply a reduction in the safety margin of the flights. This culture may have influenced the PIC's decision-making, which, despite encountering adverse conditions (below the minimum limits established by the company in its manuals), chose to take off, since the short time on the ground in the intermediate locations did not allow room for delays.

In addition, the flight planning was not carried out properly, considering that the planned schedules and routes would end, at best, at 2010 (UTC), five minutes after the closing time of the SBEG runway, provided for in the NOTAM. This meant that there was little time to adjust the legs, which could have added to the stress in the cabin.

Corroborating this, on the part of the SIC, no assertive attitude was perceived in the sense of alerting the PIC that those conditions were not favorable for takeoff. Also, it is possible that, due to possible inadequate training, the SIC did not identify the critical situation that arose soon after the take-off in time to assist the PIC in maintaining flight control.

Finally, the decision to take off, despite the meteorological training that was in the take-off sector, motivated by the operational needs listed above and, possibly, supported by the commander's extensive experience in the region, proved to be wrong, since, when leaving the ground, the accident reached its point of irreversibility, when, under IFR conditions, the plane entered an area with severe turbulence and strong descending winds, which did not allow the maintenance of a stabilized flight with a positive climb rate.

3. CONCLUSIONS.

3.1 Facts.

a) the pilots had valid CMAs;

b) the pilots had valid MNTE and IFRA Ratings;

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

d) the aircraft had a valid CA;

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

f) the technical maintenance records were updated;

g) the weather conditions were not favorable for the flight;

h) there was a NOTAM that informed the closing of the runway in SBEG, from 2005 to 0259 (UTC);

i) two aircraft, which were approaching Manaus, went to the alternative for meteorological reasons;

j) the Tower did not inform the crewmembers of significant changes in weather;

k) reports indicated that the PIC felt pressured to take off even in adverse weather conditions;

l) the take-off was carried out under heavy rain;

m) shortly after the take-off from threshold 29, the aircraft lost height and crashed in a wooded area, to the left of the runway, 600 meters from threshold 11;

n) the PT-MHC engine developed high power at the moment of impact;

o) the aircraft had substantial damage; and

p) one crewmember and five passengers suffered serious injuries and one crewmember, and three passengers suffered minor injuries.

3.2 Contributing factors.

- **Control skills – undetermined.**

While facing adverse conditions, the use of controls may have been inappropriate for the situation and may have contributed to the aircraft not being able to maintain a positive climb rate.

- **Attitude – undetermined.**

Familiarization with the region may have led to an attitude, on the part of the PIC, of minimizing the importance of analyzing adverse weather conditions, to the detriment of compliance with the minimum limits established by the company in its manuals.

- **Training – undetermined.**

It is possible that, due to possible inadequate training, the SIC did not identify the critical situation that arose shortly after the take-off in time to assist the PIC in maintaining flight control.

- **Tasks characteristics – undetermined.**

The characteristics present in the type of operation, compliance with schedules without the possibility of delays, due to the runway closing period, may have favored the self-imposed pressure on the part of the PIC, leading him to operate with reduced safety margins.

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

The conditions at the time of the take-off contributed to the aircraft not being able to maintain the flight with a positive climb rate. The probable occurrence of Windshear determined that the trajectory of the aircraft was modified until its collision with the ground.

- **Crew Resource Management – undetermined.**

On the part of the SIC, no assertive attitude was perceived in the sense of alerting the PIC that those conditions were not favorable for takeoff. Thus, the crew decided to carry out the take-off despite the company's SOP.

- **Organizational culture – undetermined.**

The company encouraged compliance with the legs even though, within the planning of flights, there was not an adequate margin of time to absorb any delays. This culture may have influenced the PIC's decision-making, which, despite encountering adverse conditions, chose to take off, since the short time on the ground in the intermediate locations did not allow room for delays.

- **Emotional state – undetermined.**

The reports indicated that the PIC felt pressured to perform the take-off even in the weather conditions found on the day of this occurrence. Also, according to the interviewees, this pressure would be related to the fulfillment of the flight schedule and the need to keep to the scheduled times. In this way, it is possible that their assessment of the performance of the flight was influenced by the stress resulting from the pressure to complete the flight within the expected time, given the closing time of the runway for works.

- **Flight planning – a contributor.**

The flight planning was not carried out properly, considering that the planned schedules and routes would end after the closing time of the SBEG runway for works,

provided for in the NOTAM. This meant that there was little time to adjust the legs, increasing the workload and stress in the cabin.

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

There was a wrong assessment of the meteorological conditions, which contributed to the decision of performing it in an adverse situation.

- **ATS publication– undetermined.**

The TWR-EG did not inform, before the take-off, of the changes in the significant weather conditions that were occurring at the terminal, which could have contributed to the PIC's decision-making.

4. SAFETY RECOMMENDATION.

A proposal of an accident investigation authority based on information derived from an investigation, made with the intention of preventing accidents or incidents and which in no case has the purpose of creating a presumption of blame or liability for an accident or incident. In addition to safety recommendations arising from accident and incident investigations, safety recommendations may result from diverse sources, including safety studies.

In consonance with the Law n°7565/1986, recommendations are made solely for the benefit of the air activity operational safety, and shall be treated as established in the NSCA 3-13 "Protocols for the Investigation of Civil Aviation Aeronautical Occurrences conducted by the Brazilian State".

Recommendations issued at the publication of this report:

To the Brazil's National Civil Aviation Agency (ANAC):

A-132/CENIPA/2019 - 01 **Issued on 09/21/2022**

Work with the Two Air Taxi Ltd. company, so that operator can carry out an operational analysis, seeking to adapt its flight planning mechanisms, in order to increase operational safety levels.

5. CORRECTIVE OR PREVENTATIVE ACTION ALREADY TAKEN.

SBEG's Air Navigation Service Provider took the following actions after the incident:

- Issued an AVOP and reinforced in the briefings, as of 18SEPT2019, the importance of weather message updates for departing and arriving aircraft, in accordance with items 5.7, 5.17, and 6.7.1.2 of ICA 100-37.

The company Two Air Taxi Ltd. took the following actions after the event:

- On 04OCT2019, Safety Alert 001/19 was published with the theme "Windshear";

- On 14OCT2019, the SOP review was carried out, with the update on the acceptable limits for operations in adverse weather conditions;

- On 11NOV2019, Operational Technical Bulletin 016/19 "Wind Limit" was published. With this publication, the company reinforced acceptable wind limits during operations;

- On 14NOV2019, Operational Technical Bulletin 018/19 "Operational Restrictions" was published;

- On 25NOV2019, Safety Alert 006/19 "Attention to NOTAM" was published to reinforce the requirements of section 11 of the company's MGO; and

- On 26NOV2019, Operational Safety Recommendation 016/19 “Operations in Restrictive Flight Conditions” was published.

On September 21th, 2022.