COMANDO DA AERONÁUTICA

CENTRO DE INVESTIGAÇÃO E PREVENÇÃO DE ACIDENTES AERONÁUTICOS

FINAL REPORT
IG - 155/CENIPA/2017

OCCURRENCE:	**SERIOUS INCIDENT**
AIRCRAFT:	**PR-MBG**
MODEL:	**A320-232**
DATE:	**30NOV2017**

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 30NOV2017 serious incident with the A320-232 aircraft model, registration PR-MBG. The serious incident was classified as “[OTHR] Other / Caused by in-flight weather phenomenon and [RE] Runway Excursion”.

During the run after landing, the aircraft crossed the left side of the runway, crashing into side beacon lights and damaging electrical boxes lids.

The aircraft had minor damage.

All the occupants left unharmed.

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

CONTENTS

GLOSSARY OF TECHNICAL TERMS AND ABBREVIATIONS

ADC	Aerodrome Chart
ANAC	Brazil's National Civil Aviation Agency
APP-BR	Brasilia Approach Control
ATS	Air Traffic Services
A/THR	Auto Thrust
BAM	Boeing Alert Monitoring
BEA	*Bureau d'Enquêtes et d'Analyses pour la Sécurité de l'Aviation Civile*
BKN	Broken (5-7 oktas)
CA	Airworthiness Certificate
CAF	Fatigue Action Call
CAS	Common Alertness Scale
CCOA	Air Operations Control Center
CENIPA	Aeronautical Accident Investigation and Prevention Center
CG	Center of Gravity
CM1	Crewmember 1 (left seat) -
CM2	Crewmember 2 (right seat)
CMA	Aeronautical Medical Certificate
CNFH	Human Fatigue National Commission
DECEA	Airspace Control Department
DSO	Operational Safety Board
EA	Airline
FAA	Federal Aviation Administration
FCOM	Flight Crew Operating Manual
FCTM	Flight Crew Techniques Manual
GEGEFA	Fatigue Management Study Group
G/S	Glide Slope
ICAO	International Civil Aviation Organization
IFR	Instrument Flight Rules
IFRA	Instrument Flight Rating - Airplane
ILS	Instrument Landing System
IMC	Instrument Meteorological Conditions
KSS	Karolinska Sleepiness Scale
LOC	Localizer
MAXCAPPI	Maximum Constant Altitude Plan Position Indicator
MCA	Aeronautics Command Manual
MEL	Minimum Equipment List
METAR	Aviation Routine Weather Report

MGO	General Operations Manual
MLW	Maximum Landing Weight
NSCA	Aeronautics Command System Standard
NTSB	National Transportation Safety Board
PCM	Commercial Pilot License – Airplane
PLA	Airline Pilot License - Airplane
PN	Part Number
PPR	Private Pilot License – Airplane
QRH	Quick Reference Handbook
RA	Radio Altimeter
REDEMET	Aeronautics Command Meteorology Network
RWY	Runway
SBBR	ICAO Location Designator - Presidente Juscelino Kubitschek International Airport, Brasília - DF
SBSN	ICAO Location Designator - Maestro Wilson Fonseca International Airport, Santarém - PA
SNA	Aeronauts National Union
SNEA	Airline Companies National Union
S/N	Serial Number
SPECI	Selected Special Aeronautical Weather Report
SSCVR	Solid State Cockpit Voice Recorder
SSFDR	Solid State Flight Data Recorder
THR	Threshold
TLA	Throttle Lever Angle
TPR	Aircraft Registration Category of Regular Public Transport
TSRA	Thunderstorm with Rain
TWR-BR	Brasilia Control Tower
TWY	Taxiway
UTC	Universal Time Coordinated
VAPP	Approach Speed
VFR	Visual Flight Rules
VLS	Lowest Selectable Speed

1. FACTUAL INFORMATION.

Aircraft	**Model:** A320-232 **Registration:** PR-MBG **Manufacturer:** Airbus Industrie	**Operator:** TAM Airlines S/A
Occurrence	**Date/time:** 30NOV2017 – 0837 (UTC) **Location:** Brasília Aerodrome **Lat.** 15°52'16''S **Long.** 047°55'07''W **Municipality – State:** Brasilia - DF	**Type(s):** [OTHR] Other and [RE] Runway Excursion **Subtype(s):** Caused by in-flight weather phenomenon

1.1 History of the flight.

The aircraft took off from the Maestro Wilson Fonseca International Aerodrome (SBSN), Santarém - PA, to the Presidente Juscelino Kubitschek International Aerodrome, Brasilia (SBBR) - DF, at about 0605 (UTC), in order to transport personnel, with 6 crewmembers and 149 passengers on board.

During the run after landing on SBBR, the aircraft crossed the left side limit of the runway (veer off), crashing into some beacon lights and damaging electrical boxes lids.

The aircraft had minor damage.

All occupants left unharmed.

1.2 Injuries to persons.

Injuries	Crew	Passengers	Others
Fatal	-	-	-
Serious	-	-	-
Minor	-	-	-
None	6	149	-

1.3 Damage to the aircraft.

The aircraft had minor damage restricted to the tires of the left main landing gear, wheels nº 1 and nº 2.

1.4 Other damage.

Damage to four beacon lights and four boxes of electrical passage, all from SBBR runway 11L / 29R.

1.5 Personnel information.

1.5.1 Crew's flight experience.

Flight Hours		
	Pilot	Copilot
Total	11.346:00	6.900:00
Total in the last 30 days	83:30	80:25
Total in the last 24 hours	08:05	05:15
In this type of aircraft	8.128:55	4.710:40
In this type in the last 30 days	78:15	74:30
In this type in the last 24 hours	08:05	05:15

N.B.: The data related to the flown hours were obtained through the records given by the Airline.

1.5.2 Personnel training.

The commander, a crewmember who occupied the left seat (CM1), took the Professional Pilot Course in Southwind, Texas - USA, in 1994.

The copilot, a crewmember who occupied the right seat (CM2), took the PPR License at the São Paulo Aeroclub - SP, in 2002.

1.5.3 Category of licenses and validity of certificates.

The Commander had the PLA License and had valid A320 aircraft type Rating (which included the A320-232 model) and IFRA Rating.

The Copilot had the PCM License and had valid A320 aircraft type Rating (which included the A320-232 model) and IFRA Rating.

1.5.4 Qualification and flight experience.

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

1.5.5 Validity of medical certificate.

The pilots had valid CMAs.

1.6 Aircraft information.

The aircraft, serial number 1459, was manufactured by *Airbus Industrie*, in 2001 and it was registered in the TPR category.

The aircraft had valid Airworthiness Certificate (CA).

The technical maintenance records were updated.

The aircraft was equipped with engines manufactured by International Aero Engines AG (IAE), series V2527-A5 and had the following operational limitation: Auto Thrust (A / THR) OFF, since 27NOV2017, the operation being in accordance with the List of Minimum Equipment (MEL) 22-30-01A.

1.7 Meteorological information.

The event took place about seven minutes after the calculated sunrise time in Brasilia - DF, which corresponded to the sun in the direction of 112º and at an angle of 1° above the horizon line (Figure 1).

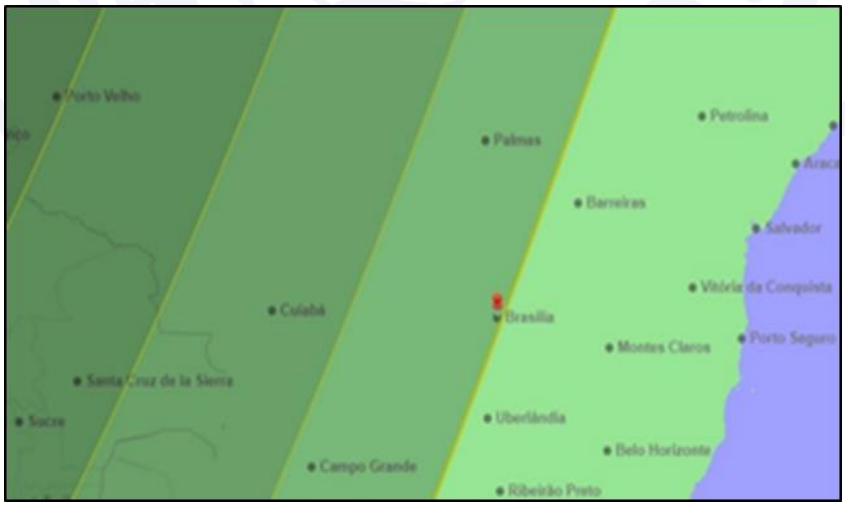


Figure 1 - Sun position at the time of the event.
(Source: in-the-sky.org).

The sunrise time, registered at the DECEA's Aeronautical Information Service table, for 30NOV2017, in the locality of SBBR, was at 0830 (UTC).

In addition to the time close to sunrise, the field operated under IMC, with the present weather showing a cloud ceiling at 500 feet (BKN005), heavy rain with thunderstorm (+ TSRA) and variable wind of 140º to 230º, with intensity from 10kt to 22kt (18010G22KT 140V230), according to information contained in the SPECI:

> SPECI SBBR 300836Z 18010G22KT 140V230 0500 R11L/P2000 R29R/P2000 R11R/1300 R29L/P2000 +TSRA BKN005 FEW017CB 19/18 Q1015=

The adverse condition was communicated by the Brasilia Approach Control (APP-BR) to the aircraft, moments before it entered the final approach, and the crew informed that they knew about the conditions, as transcribed from the cabin's audio recording.

The images obtained in the REDEMET, of the MAXCAPPI, from the weather radar of São Francisco - MG, from 30NOV2017, at 0837 (UTC), showed, in the Brasilia region, the presence of precipitation in shades that varied from blue (very light rain) to green and yellow (light and moderate rain) (Figure 2).

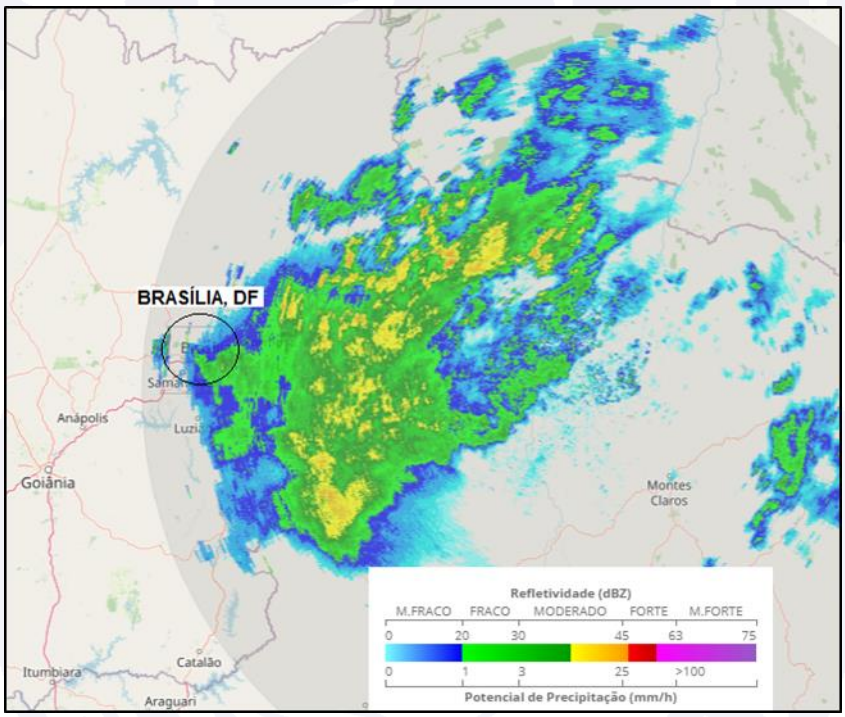


Figure 2 - MAXCAPPI image of Brasília - DF, from 0837 (UTC), on 27NOV2017.

To record the times described in this field, the Coordinated Universal Time (UTC) was used as a reference.

1.8 Aids to navigation.

All navigation and landing aids operated normally when the aircraft was approaching, including instrument approach, Instrument Landing System (ILS) Y RWY 11L, used during approach (Figure 3).

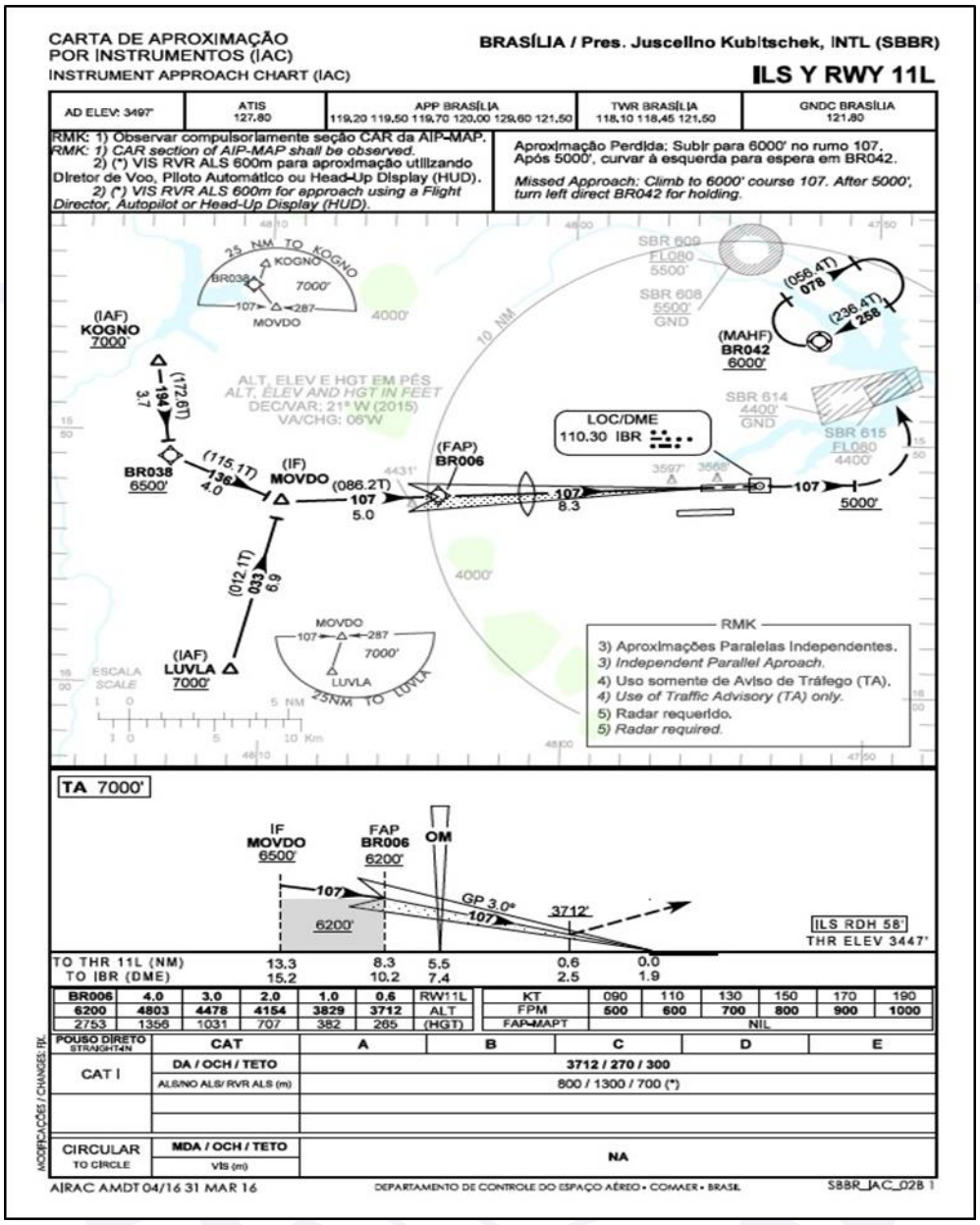


Figure 3 - ILS Y RWY 11L chart from SBBR.

1.9 Communications.

According to the transcripts of the communication audios between the PR-MBG and the control agencies, it was found that the crew maintained radio contact with the APP-BR and with the TWR-BR, and there was no technical abnormality of communication equipment during the flight.

In order to support the analysis of the sequence of events that preceded the aircraft's runway departure, the Investigation Team highlighted some transmission that helped in understanding the dynamics of the accident.

At 08h22min51s, the CM1 started the missed approach procedure, as the aircraft was destabilized and the wind was above the landing limit.

At 08h32min51s, the APP-BR informed about heavy rain in the airfield and report of slippery runway: “TAM 3081, I inform heavy rain on the airfield and there has already been a report of slippery runway”.

At 08h33min00s, the crew reported awareness of the runway conditions: “Okay, thanks for the information, TAM 3081”.

At 08h34min31s, the TWR-BR authorizes the landing on runway 11L and informs about the report of slippery runway and heavy rain: “TAM 3081 the runway is free, landing authorized. I inform you that there was report of slippery runway, adjustment of one zero five, heavy rain”.

At 08h37min03s, right after the aircraft's automatic callout announces the height of 5ft, the CM2 shows concern about the runway axis: “look, the axis”, repeating the alert 3 seconds later: “the axis”.

After landing, at 08h37min59s, the crewmembers initiate a dialogue about whether the aircraft has left the runway or not, CM1: “do you think it touched off, or not?”, CM2: “yeah, I don't know, I was in doubt”.

At 08h38min59s, the crewmembers ask TWR-BR to carry out an inspection on the runway, to check if the aircraft landed within its limits: “3081 is clearing here on the last one and kindly requests an inspection after the rain... a little ahead of the touching area, on the left side of the runway, okay? I'm not sure if I touched within the limits of the runway”.

1.10 Aerodrome information.

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

The runways were made of asphalt, with thresholds 11L / 29R and 11R / 29L, dimensions of 3,200m x 45m and 3,300m x 45m, with an elevation of 3,497ft (Figure 4).

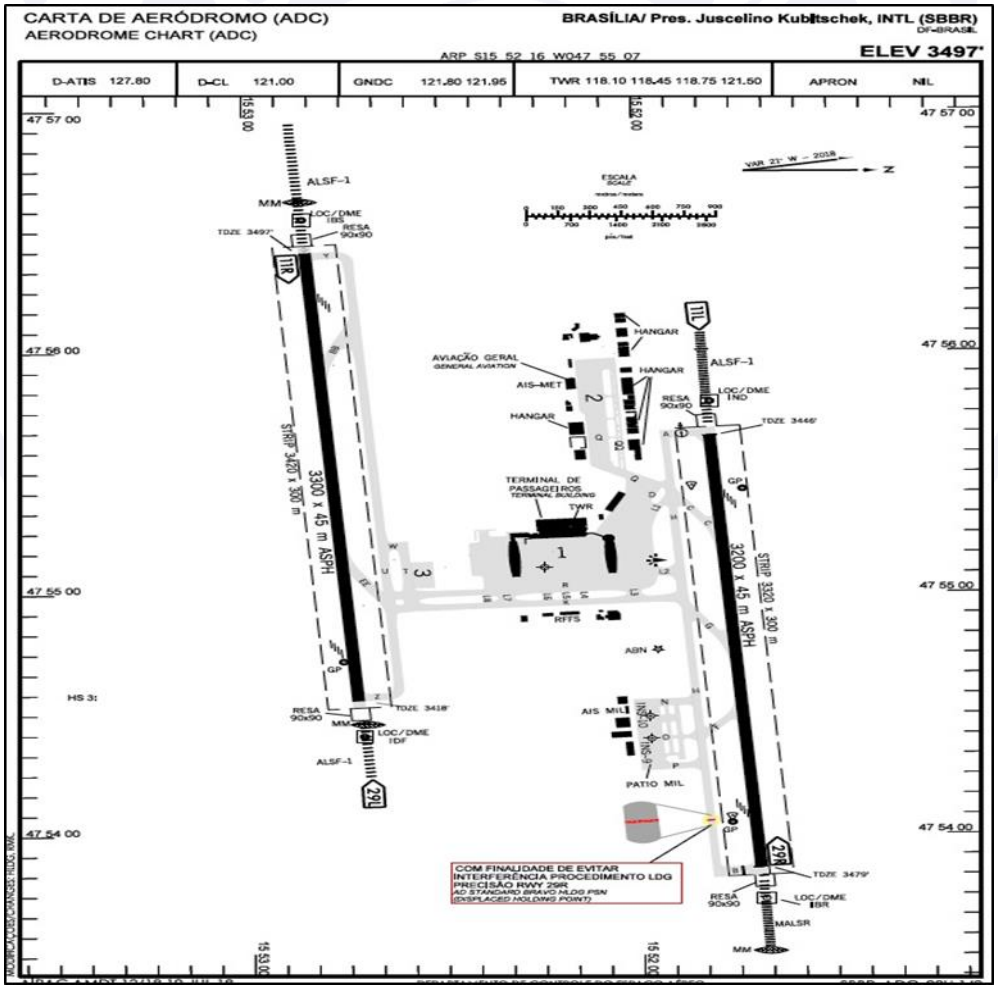


Figure 4 - SBBR Aerodrome Chart (ADC).

The threshold used for landing was the 11L, which had a magnetic approach heading at 107º.

1.11 Flight recorders.

The aircraft was equipped with a HONEYWELL Flight Data Recorder (SSFDR), Part Number (PN) 980-4700-042, S / N 16432, and a HONEYWELL Cabin Voice Recorder (SSCVR), PN 980-6022- 001, S / N CVR120-12698.

The SSFDR and SSCVR were sent to the CENIPA's LABDATA to carry out the data readings and communications maintained by the crew in the cockpit.

According to the data recorded in the SSFDR, ten seconds before landing, the wind direction was 154º and the intensity was 22kt (Figure 5), at the time of landing, the direction had changed to 181º and the intensity increased to 25kt (Figure 6).

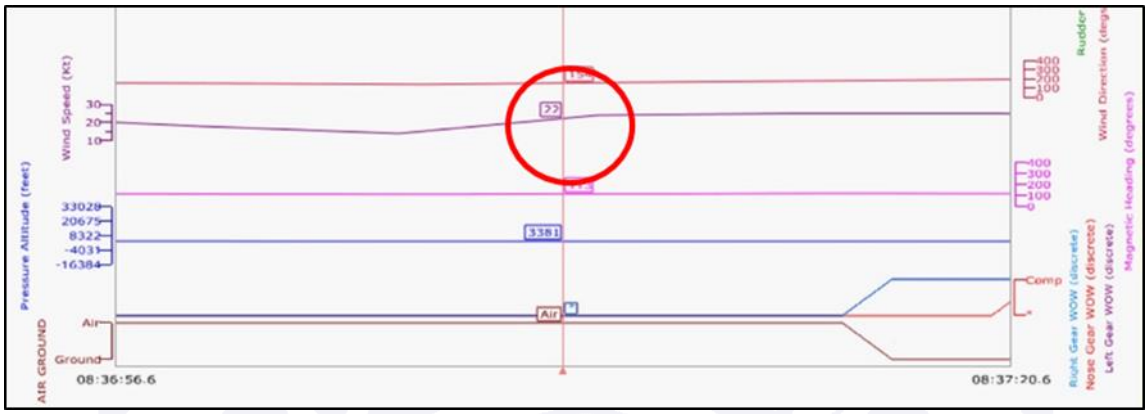


Figure 5 - Wind ten seconds before touch (154° / 22kt).

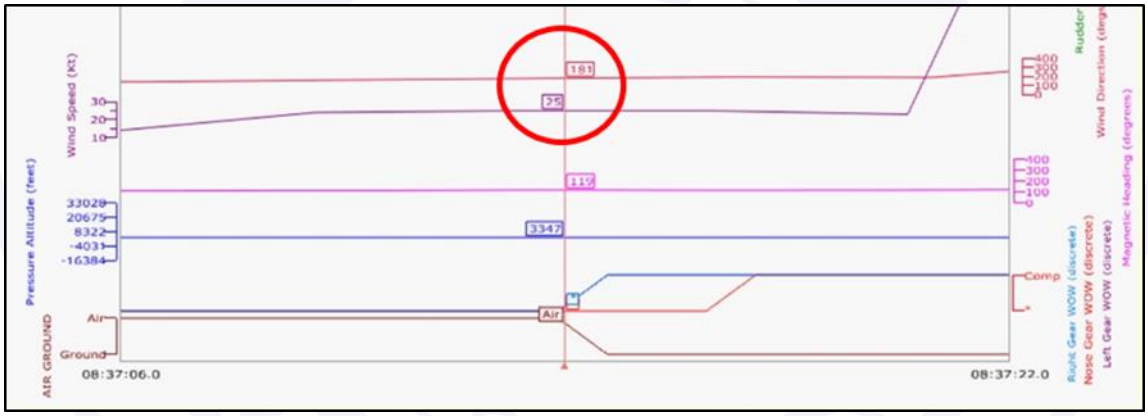


Figure 6 - Wind at the moment of touch (181° / 25kt).

Also according to SSFDR data, at 1,000ft of Radio Altimeter (RA), the aircraft was in the following configuration:

- 61.5ton weight - less than the Maximum Landing Weight (MLW) = 64.5ton;
- Slats at 27º and Flaps at 40º (FULL configuration);
- Ground spoilers set up;
- Auto brake set up in Medium (MED);
- The two flight directors engaged in the ILS: Locator (LOC) and Ramp (G / S);
- Auto Thrust (A / THR) OFF;
- Reference Speed (VLS) - 125kt;
- Approach Speed (VAPP) - 135kt, VAPP = VLS + 10kt;
- Calibrated speed - 135kt;

• Descent Rate at 900ft / min;

• Pitch angle at + 1° (nose up);

• Heading in 116°;

• Drift angle in 9º (runway course = 107º); and

• Aircraft stabilized in the ILS trajectory (LOC and G / S).

From 1,000ft until the moment of decoupling the autopilot, which occurred at 100ft RA, the aircraft presented:

• Trajectory at LOC and Glide Slope;

• Variations in pitch from 0 to + 4º;

• Speed variations between 135kt (VAPP) and 149kt (VAPP + 14kt);

• Descent rate between 440ft / min and 900ft / min;

• Variations in the throttle of engine 1 between 6º and 11º of Throttle Lever Angle (TLA);

• Variations in the throttle of engine 2 between 8º and 14º of TLA; and

• Heading between 116º and 113º (drift between 9º and 6º to the right, respectively).

From 100ft until the touch:

• Gradually increasing the pitch angle from 1º to 5,2º;

• Reduction in the descent rate from 700ft to 100ft;

• Reduction of the levers for IDLE and start of the FLARE with approximately 80ft RA;

• Rapid increase of the lateral wind component from 10kt to 20kt, just before the touch;

• Left pedal commands when close to 30ft RA followed by commanding the right pedal;

• Drift angle reduced from 7º to 5º and then increased to 11º.

1.12 Wreckage and impact information.

During landing, there was an impact between the tires of the left main landing gear, wheels numbers one and two, and four side markings on the runway 11L / 29R (Figures 7 and 8).

Figure 7 - Damage to the vertical markings of runway 11L.

Figure 8 - Sketch with the positioning of the damaged markings.
(Source: Google Earth).

Due to the passage of the wheels of the left landing gear out of the runway, there were also failures in four electrical passage boxes (Figure 9).

Figure 9 - Damaged electrical passage boxes.

The collision was confirmed after the airport operator performed an inspection on the runway, using the “Oscar-Uno” vehicle, and due to the visualization of damage to the external tire of the left main landing gear, when the PR-MBG aircraft was parked at position 18 of the Aerodrome (Figure 10).

Figure 10 - Damage to the tire of the left main landing gear.

In total, four markings and four electrical boxes lids were damaged, as well as two aircraft tires.

1.13 Medical and pathological information.

1.13.1 Medical aspects.

Not investigated.

1.13.2 Ergonomic information.

Nil.

1.13.3 Psychological aspects.

The CM1 had been with the company for almost twenty years, in which he had the reference of being a good pilot, due to his operational performance. Company professionals defined his work profile as that of a person who always sought to fulfill what was assigned to him.

The Copilot had been with the company for seven and a half years. The Company considered both, he and the CM1, to be experienced pilots. The CM1 was seen as having a more agitated profile and the copilot, a more relaxed one.

The operational base of the CM1 was in Brasília, a place for which, at the time of the occurrence, he was organizing himself to move to and the copilot base was in São Paulo. The two crewmembers had already flown together about two years ago.

This occurrence was the first CM1 event at the company. The copilot had already gone through an incident, in which he provided good advice in flight and, for that reason, the occurrence became a case study for the training conducted by the company.

The CM1 commented to the copilot about his fatigue and also about the flight rosters at dawn he had been carrying out. According to the copilot, the CM1 looked tired. Through the flight's CVR, it was possible to hear the CM1 yawning.

The entire flight crew, with the exception of the copilot, spoke of fatigue, due to flights at dawn, and this matter was even addressed in the beginning of the schedule briefing.

The copilot had a break on 28NOV2017 and started a new flight roster on 29NOV2017 at 1135 pm (local time), however he reported not having rested properly during the break, as he was accompanying a family member in a hospital emergency.

On the first flight stage of the day 29NOV2017, the copilot informed that he was unable to have a good rest in Brasilia, because he had difficulty resting well during daytime periods.

Regarding the occurrence flight, the copilot reported that he did not interfere in the operation, as he trusted the CM1 experience. During the landing approaches made by the CM1, he did not feel comfortable, but for the reasons mentioned above, he did not make any more assertive interventions.

Just before the touch, according to the CVR record, the copilot mentioned the runway's axis, having repeated the message three seconds later. He also stated that he saw no reason to decide for a new go-around procedure during the second landing approach in Brasilia.

The copilot said that they did not adequately absorb the content passed by TWR - BR, which reported heavy rain and slippery runway. However, it was possible to verify, through the CVR, that the crewmembers collated and commented on this information.

Still on the flight, the copilot reported that it was not common to fly without Auto Thrust, but that he went through training for this type of situation. Despite this, he expressed that this condition caused discomfort, as he was not used to flying in contexts like this.

From the CVR data, it was found that the crew, during the checklist for landing, aligned the actions for its realization, defining Goiânia as an alternative, in case they were unable to land in Brasília.

After touching the runway, the CM1 and the copilot were in doubt as to whether the aircraft had left the runway or not. Thus, the CM1 requested TWR-BR inspection.

According to the interviews, the pilots felt overwhelmed during the operation in the final approach. In the copilot's opinion, operating without Auto Thrust increased the workload, which was accentuated in rainy scenarios.

1.14 Fire.

There was no fire.

1.15 Survival aspects.

Nil.

1.16 Tests and research.

Nil.

1.17 Organizational and management information.

The company had in Brazil, about 2,000 pilots, 1,200 of them in the role of copilot, and around 6,000 flight attendants to serve the entire network offered.

The rosters of the technical crew (pilots) and cabin (flight attendants) of the Brazil's branch were already under the responsibility of the Schedule Planning Team, installed at the Corporate in Santiago de Chile and received specific, manual and final adjustments from the Schedule Execution Team, based in Brazil. The management of these teams was shared between the Corporate Vice-Presidency of Operations, the Directorate of the CCOA, Schedule Brazil and the Directorate of Operations Brazil.

The rosters of all technical and cabin crewmembers of the company were planned by the Corporate Schedule Planning Team and the rosters of all technical and cabin crewmembers of the Brazil's branch were under the responsibility of this Team, since 2016. For the elaboration of these services, the Schedule Planning had an Optimizing System called CARMEN, from JEPPENSEN.

This system was characterized by company professionals as a generalist one, as it did not take into account the specificities and particularities of some LATAM operations. Consequently, when designing a stopover for Brazil, for example, the restricted runways were not considered, nor the periods in which airports commonly closed due to meteorology. The system also allowed manual changes to be made, in order to adjust specific demands when planning the rosters.

In addition, for Schedule Planning, some rules called by the company as "hard rules" should be considered, such as the Aeronaut Law and the Collective Agreement, Cost rules from the Commercial sector; Quality of Life rules; rules for the Management of Fatigue Risk, among others, as needed.

Pilots' and Flight attendants' rosters received practically the same treatment by the Schedule Planning. However, some rules were different, depending on the specificities of the activities developed. Thus, the pilots were distributed by type of aircraft, in which those who flew Boeing did not fly Airbus and vice versa; while flight attendants could be assigned to both types. For schedule analysis, in relation to fatigue, the characteristics and complexity of each activity (pilot and flight attendant) were also considered, in order to assess the risk margin involved.

The company also had a bio mathematical model, known as Boeing Alert Monitoring (BAM), which interacted with the CARMEN Optimizer System, since 2016. BAM considered the period of activity (awake) in flight, pointed out the points outside the fatigue limit and indicated the level of alertness of the crewmembers in the critical phases of the flight. However, it did not require changing in the schedule when identifying sensitive points.

On the flight that originated the occurrence, when creating a schedule that went against the company's rule of operating at dawn, the CARMEN System auto-adjusted itself, anticipating the presentation for the final half hour (11:35 pm - local) of the previous day (29NOV2017), which made the flight more critical to fatigue. According to this rule, the crewmember could have two presentations at dawn and, if there were presentations on sequential days, these should be after 6:00 am and 8:00 am (Dawn - Dawn - 06h00min - 08h00min).

It is noteworthy that the CM1, on 29NOV2017, had presented himself at 06:05 am (local) in Brasilia to perform the legs Brasilia-Confins-Brasilia, with an estimated time of arrival in SBBR at 10:06 am (local). On that day, CM1 had a statutory rest in Brasilia and presented for a new day at 11:35 pm (local).

The Schedule Execution Team received the rosters from the technical and cabin crewmembers of the Brazil's branch from the Schedule Planning, usually between the 25th and 26th of the month, prior to their completion.

The DSO, through the Human Factors Team, was responsible for matters related to fatigue risk management in the company and the gaps found in this area were reported to the teams that participated in the development of this process with the company. This team was also responsible for raising awareness among the technical and cabin crew of the Brazil's branch about the importance of reporting fatigue, when necessary.

The duty roster was generally released to crewmembers at least five working days in advance of the following month, as established by the Aeronaut Law.

When the technical or cabin crewmember identified any schedule that could be compromised due to fatigue hazards, he could request analysis of his roster from the DSO, through the Human Factors Team. If the impairment of the crew's activity was identified due to fatigue issues, the Human Factors Team sent the Schedule Execution Team a recommendation for the one-off and prompt change of that schedule to that crewmember.

In addition, there was a communication channel for fatigue reports on the roster through the Fatigue Action Call (CAF). The service of this channel was in charge of the Call Center, located in the Schedule Execution sector. Its use was intended for crewmembers to report fatigue in the last 12 hours prior to their schedule.

After the call, the crewmember should send a report on the matter within 24 hours to the DSO Human Factors Team, which would evaluate that call and the symptoms described by the crewmember.

In a survey carried out with the Schedule Execution sector, it was identified that, in November 2017, 54 CAF were received and in December, after this occurrence, 32 CAF. However, these data were from calls not yet analyzed. Therefore, there was a possibility that there were cases not classified as fatigue.

In the periods previous to the last 12 hours prior to the flight, technical or cabin crewmembers could request a roster analysis from the DSO's Human Factors Team.

The interventions on the schedules, identified as necessary, were passed on to the teams that were part of the fatigue risk management, where the Human Factors Team presented these indicators monthly, aiming at the continuous improvement of this process in the organizational scope.

The company established, in addition to the rules in force in the Regulation of the Aeronaut and in the Collective Agreement, a rule for the operation of flights at dawn, in which the crewmember could have two presentations during that period, and after those two days, he should have presentations in periods that did not involve flights at dawn. Thus, the crewmember could have two sequential dawns on his roster, at increasing times; and in the next days of the schedule, flights should start after 6:00 am and 8:00 am, respectively.

The schedules were planned by the Corporative in Chile, in accordance with the management of the CCOA, Schedule and Operations Board in Brazil; however, they were susceptible to undergo necessary changes or adjustments.

The company had a GEGEFA to address the issues identified in the company's operation regarding this topic. It was a corporate group, involving corporate and local boards, both in Chile and Brazil. Group meetings were held monthly in Brazil and coordinated by the local Human Factors Team.

In addition to this group, there was a Control Center for decisions that impacted the flight, formed by the Flight Coordination, Schedule Execution, Maintenance and Airport Central functions.

For the event in question, the CM1 flight roster (Figure 11) and that of the flight attendants had a schedule of consecutive days of flight, with flights on following days, in which the majority of the presentations or awakenings of the crewmembers occurred at dawn. However, no fatigue analysis requests for these schedules by the crew were found.

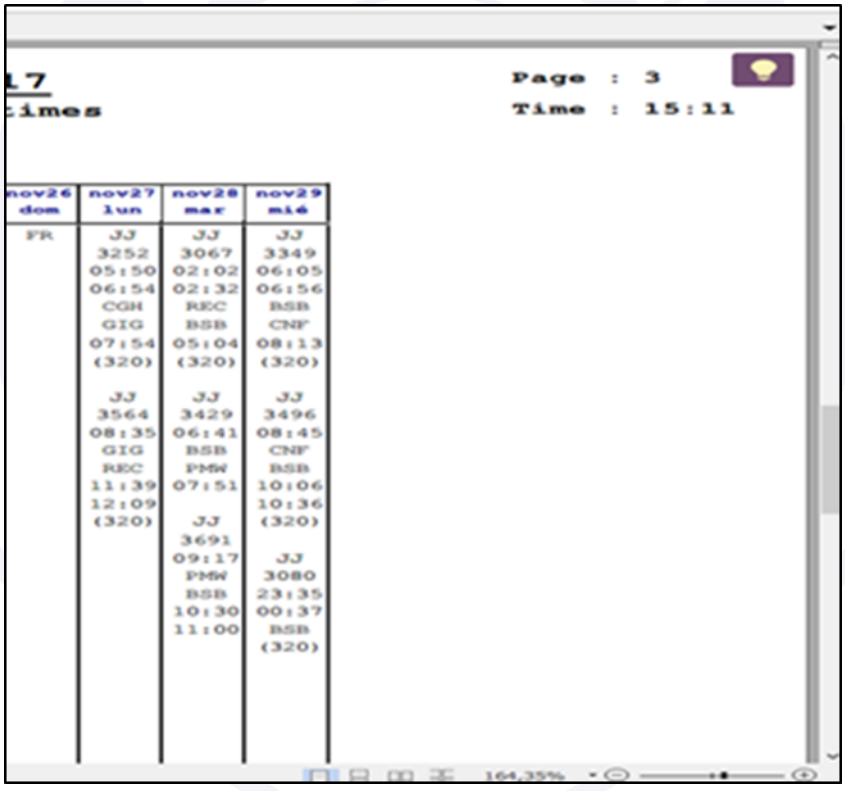


Figure 11 - Statement from the CM1 flight roster.

It is worth mentioning that, during the investigation, it was raised that, as some reports of fatigue were not considered valid by the company, there were crewmembers who expressed resistance to report fatigue condition, for fear of not having their report validated.

Soon after this occurrence, the crew's roster was analyzed by the company's own team, and it was verified that both the CM1 and the flight attendants had a flight schedule susceptible to fatigue during the occurrence period.

This analysis was based on the NTSB fatigue investigation protocols, the Human Fatigue Investigation Guide for Aeronautical Occurrences of the CNFH, the waking hours and crew presentation, at the limit established internally for the BAM System, in the Crew Alert analysis, in the human factor and fatigue forms applied after the events and in the analysis of the pairing (flight schedules, without crew distribution), roster (published flight schedule) and executed schedule .

The programming of the flight scheduled of the CM1 was at level 1,696 by the BAM System which, although it can be considered a high level of fatigue, it was considered acceptable by the company. At the time of the event, the fatigue level of the CM1 was 1,014.

BAM was based on a three-process alert model, which considered the following related aspects:

- Process C - circadian rhythms;

- Process S - sleep-wake homeostasis; and

- Process W - waking.

It should be noted that the system issued results of alert levels ranging from 0 to 10,000, based on the CAS, with 0 corresponding to the lowest alert level and, therefore, the highest risk of fatigue.

In addition, the system had a correspondence with the Karolinska Sleepiness Scale (KSS), which was a method of assessing sleepiness.

This scale had a measurement from 1 to 9 points, in which 1 (extremely alert) corresponded to the maximum level of alert and 9 (extremely sleepy, fighting sleep) to the maximum level of drowsiness and, therefore, greater risk of fatigue, as shown in Figure 12.

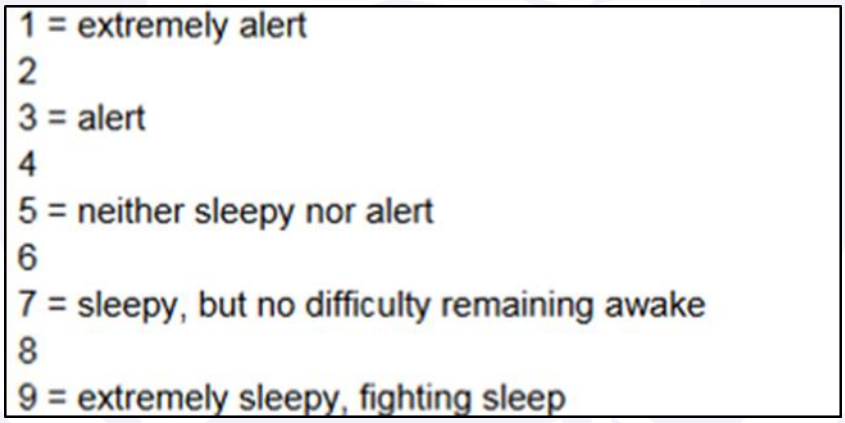


Figure 12 - Karolinska Sleepiness Scale.
(Source: Manual for the Oversight of Fatigue Management Approaches (Doc 9966) 2nd Edition2016).

According to the studies that supported the development of the scale, the criterion of excessive sleepiness was adopted for values equal to or above 7, since, from that level, it would be possible to identify the first signs of changes in neurological activity patterns, compared to the waking pattern.

To calculate the correspondence between the scales, the following formula was adopted: KSS = 9 - CAS / 1.250.

In this context, the level shown in the CM1 flight roster programming in the BAM System (1,696) was equivalent to the level 8 in the KSS and, at the time of the occurrence (BAM = 1,014), it was at the 7.6 level of the KSS.

Referring to the operational training offered by the company to the pilots, it was found that the training of the operation without the Auto Thrust was carried out in a simulator.

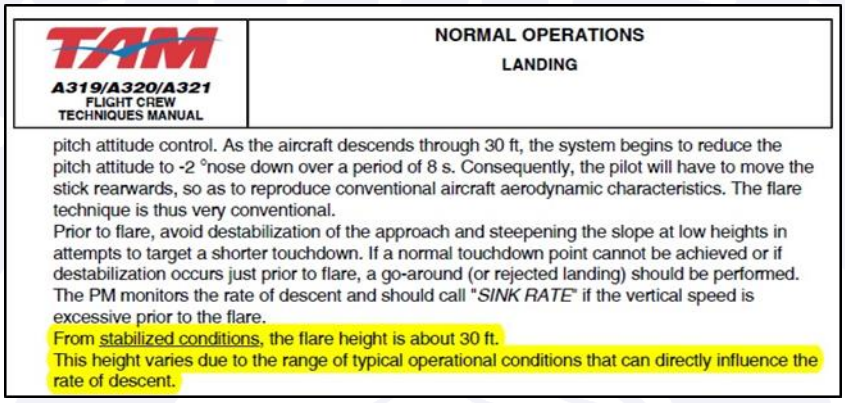
Regarding the work environment, there was, according to reports, a good organizational climate.

1.18 Operational information.

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

Since 27NOV2017, the aircraft was operating with the A / THR OFF, meeting the requirements of MEL 22-30-01A.

The FCTM of the Airline Company prevised that, in stabilized conditions, the reference height for performing the FLARE would be around 30ft, and that height could vary depending on the operational conditions that directly influenced in the descent rate (Figure 13).



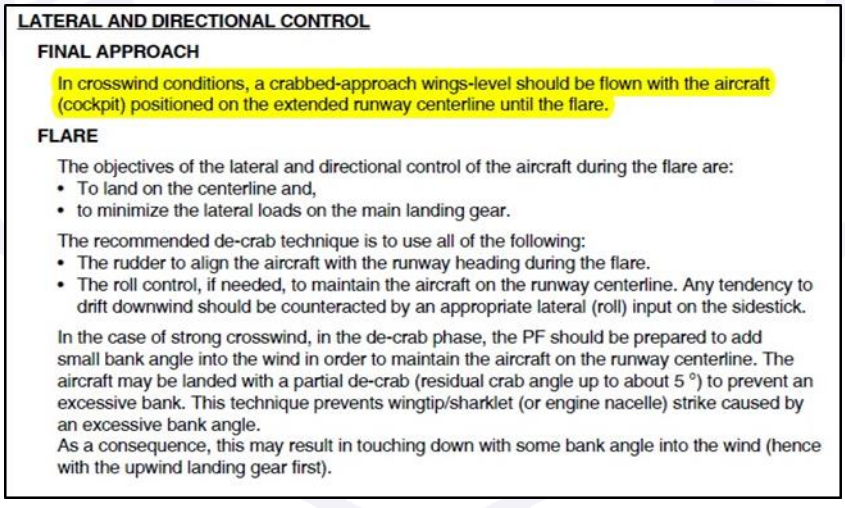
TAM
A319/A320/A321
FLIGHT CREW
TECHNIQUES MANUAL

NORMAL OPERATIONS
LANDING

pitch attitude control. As the aircraft descends through 30 ft, the system begins to reduce the pitch attitude to -2 °nose down over a period of 8 s. Consequently, the pilot will have to move the stick rearwards, so as to reproduce conventional aircraft aerodynamic characteristics. The flare technique is thus very conventional.
Prior to flare, avoid destabilization of the approach and steepening the slope at low heights in attempts to target a shorter touchdown. If a normal touchdown point cannot be achieved or if destabilization occurs just prior to flare, a go-around (or rejected landing) should be performed.
The PM monitors the rate of descent and should call "*SINK RATE*" if the vertical speed is excessive prior to the flare.
From stabilized conditions, the flare height is about 30 ft.
This height varies due to the range of typical operational conditions that can directly influence the rate of descent.

Figure 13 - TAM A319/A320/A321 FLEET FCTM NO-170 P 2/14.

The same manual also prevised that, to compensate for the side wind component, the crabbed-approach technique was used until FLARE, then use the technique of lowering the wing to the wind side and utilize the rudder to align the fuselage with the runway axis (Figure 14).



LATERAL AND DIRECTIONAL CONTROL

FINAL APPROACH

In crosswind conditions, a crabbed-approach wings-level should be flown with the aircraft (cockpit) positioned on the extended runway centerline until the flare.

FLARE

The objectives of the lateral and directional control of the aircraft during the flare are:
- To land on the centerline and,
- to minimize the lateral loads on the main landing gear.

The recommended de-crab technique is to use all of the following:
- The rudder to align the aircraft with the runway heading during the flare.
- The roll control, if needed, to maintain the aircraft on the runway centerline. Any tendency to drift downwind should be counteracted by an appropriate lateral (roll) input on the sidestick.

In the case of strong crosswind, in the de-crab phase, the PF should be prepared to add small bank angle into the wind in order to maintain the aircraft on the runway centerline. The aircraft may be landed with a partial de-crab (residual crab angle up to about 5 °) to prevent an excessive bank. This technique prevents wingtip/sharklet (or engine nacelle) strike caused by an excessive bank angle.
As a consequence, this may result in touching down with some bank angle into the wind (hence with the upwind landing gear first).

Figure 14 - TAM A319/A320/A321 FLEET FCTM NO-170 P 3/14.

As per the Quick Reference Handbook (QRH), section In-Flight Performance, Landing Performance Determination, VAPP Determination without Failure, in case of strong or gusty crosswind greater than 20kt, VAPP should be at least VLS + 5kt. The 5kt increment above VLS may be increased up to 15kt at the flight crew's discretion (Figure 15). During the event, the flight crew selected a target speed VAPP=VLS + 10kt, in accordance with the above QRH guidance.

Note: In case of strong or gusty crosswind greater than 20kt, VAPP should be at least VLS + 5 kt. The 5kt increment above VLS may be increased up to 15kt at the flight crew's discretion.

Figure 15 - Statement from the QRH (VAPP Determination without Failure).

The company's MGO stipulated that the crosswind component limit for the Airbus fleet operating on wet runways would be 18kt.

According to the manufacturer's manual, the FCOM, the wind limit for landing with the runway in wet and slippery condition would be 25kt.

1.19 Additional information.

- Law N° 13,475 of 28AGO2017 – Aeronaut Law

The Law, in its Art. 5, established that:

> Art. 5 The flight and cabin crew perform their professional functions in the following air services:
>
> I - regular and non-regular public air transport service, except in the air taxi category;

Regarding the limits of working hours in this category, Section V of the aforementioned law, in its Article 42, provided that:

> The maximum limit of 2 (two) consecutive nights of work will be observed, and that of 4 (four) total nights in the period of 168 (one hundred and sixty-eight) consecutive hours, counted since the presentation of the crewmember.

Still on Art. 42, it specified in its items that:

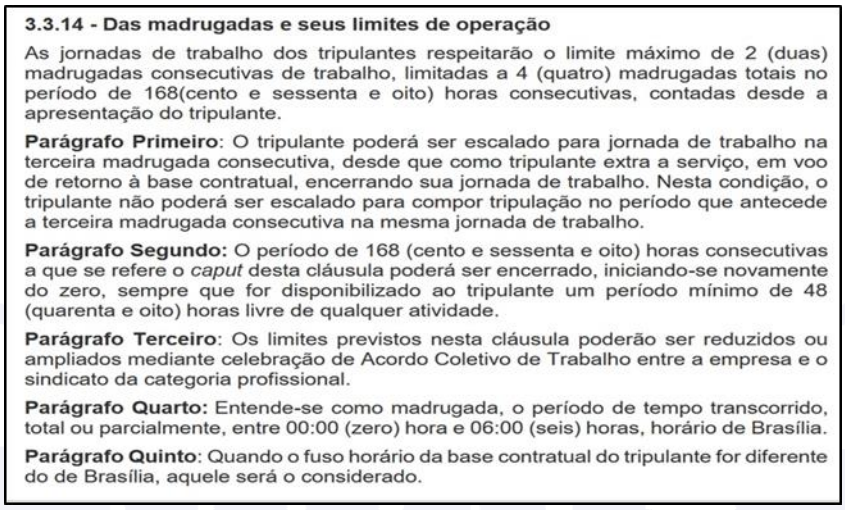
> § 1st The flight or cabin crewmember may be scheduled for work on the third consecutive dawn, provided that as an extra crewmember, on a return flight to the contractual basis and ending his / her working day, in this case, the crewmember is not allowed to compose a crew in the period before the third consecutive dawn on the same working day.
>
> § 2nd. Whenever a minimum period of 48 (forty-eight) hours is available to the crewmember free of any activity, the counting of a new period of 168 (one hundred and sixty-eight) consecutive hours referred to in the caput of this article may begin.
>
> § 3rd The limits prevised in this article may be reduced or increased by means of a collective labor agreement or convention, provided that they do not exceed the parameters established in the regulations of the Brazilian civil aviation authority.
>
> § 4th The period elapsed, wholly or partially, between 0 (zero) hour and 6 (six) hours is considered to be dawn, considering the official time zone of the crew's contractual base.

- Regular Aviation Collective Labor Convention - 2017/2018 - SNA / SNEA

The conditions present in this convention covered the aeronauts that operated throughout the national territory, also including the crew of airlines that were based or operated abroad.

This Convention, in line with the Aeronaut Law, allowed two dawns in a row, reaching four dawns in the 168-hour period.

On the third day, the crewmember could only be scheduled for working at dawn if he was on extra time returning to his base. At the end of the 168-hour period, the crewmember would need to have 48 hours free of activities (Figure 16).



3.3.14 - Das madrugadas e seus limites de operação

As jornadas de trabalho dos tripulantes respeitarão o limite máximo de 2 (duas) madrugadas consecutivas de trabalho, limitadas a 4 (quatro) madrugadas totais no período de 168(cento e sessenta e oito) horas consecutivas, contadas desde a apresentação do tripulante.

Parágrafo Primeiro: O tripulante poderá ser escalado para jornada de trabalho na terceira madrugada consecutiva, desde que como tripulante extra a serviço, em voo de retorno à base contratual, encerrando sua jornada de trabalho. Nesta condição, o tripulante não poderá ser escalado para compor tripulação no período que antecede a terceira madrugada consecutiva na mesma jornada de trabalho.

Parágrafo Segundo: O período de 168 (cento e sessenta e oito) horas consecutivas a que se refere o *caput* desta cláusula poderá ser encerrado, iniciando-se novamente do zero, sempre que for disponibilizado ao tripulante um período mínimo de 48 (quarenta e oito) horas livre de qualquer atividade.

Parágrafo Terceiro: Os limites previstos nesta cláusula poderão ser reduzidos ou ampliados mediante celebração de Acordo Coletivo de Trabalho entre a empresa e o sindicato da categoria profissional.

Parágrafo Quarto: Entende-se como madrugada, o período de tempo transcorrido, total ou parcialmente, entre 00:00 (zero) hora e 06:00 (seis) horas, horário de Brasília.

Parágrafo Quinto: Quando o fuso horário da base contratual do tripulante for diferente do de Brasília, aquele será o considerado.

Figure 16 - Statement from the Regular Aviation Collective Labor Convention - 2017/2018, p. 17.

- Collective Agreement of the Company with the Union of the Category

In an agreement established between the company and the Crewmembers' Union, it was established that the journey could have two dawns in a row, reaching four dawns in the period of 168 hours.

The crewmember could only be scheduled for the third dawn, if he was on extra crew, returning to his base. At the end of the 168-hour period, the crew would need to have 48 hours of rest, when at least two opportunities for nighttime sleep should be offered.

- Doc 9966 da ICAO - Manual for the Oversight of Fatigue Management Approaches

This manual, the second edition of which was published in 2016, guided the implementation of fatigue management for crewmembers and highlighted the impact that continuous or prolonged waking hours had on human performance.

- Human Fatigue Investigation Guide in Aeronautical Occurrences

During the investigative process, the investigative methodology developed by the CNFH was used in the initial interviews to identify the possibility of fatigue in this event.

- Flight Operations Briefing Notes - Human Performance - Visual Illusions Awareness, REV. 2, SEP2005, AIRBUS.

According to the study carried out by AIRBUS, visual illusions can occur when environmental conditions change the pilot's perception of his expectations.

These illusions can result in landings below / beyond the runway (USO

S), hard landing, runway excursion (RE), as well as spatial disorientation and loss of control (LOC-I).

Still according to the document, the statistical data reveal that:

> …Low visibility and/or precipitations are a circumstantial factor in more than 70 % of approach-and-landing accidents, including those involving CFIT.

- MCA 100-16, Air Traffic Phraseology

The MCA 100-16, of 11FEB2016, in force at the time of the occurrence, which had the purpose of establishing air traffic phraseology standards, described that, on the Final Approach, when the landing authorization was given, the Control Tower should inform the wind direction and intensity (Figure 17):

3.4.3.3.2 Resposta

a) indicativo da aeronave;

b) autorização;

c) direção e velocidade do vento; e

d) instruções complementares (se houver).

TAM 3702, avistado, pouso autorizado, vento 095 graus/12kt.	TAM 3702, I have you in sight, cleared to land, wind 095 degrees/12kt.
GLO 1671, pouso autorizado, vento 120 graus /10kt.	GLO 1671, cleared to land, wind 120 degrees/ 10 kt.
(a) observe máquina próxima margem direita da pista em uso.	(a) observe machine near right side of the runway in use.
(b) observe homens trabalhando próximo da cabeceira em uso.	(b) observe men working near the threshold of the runway in use.

Figure 17 - Standardized phraseology in the final approach prevised in Chapter 3 - Standardized phraseologies, Section 3.3 - Approach Control Service, Item 3.4.3 - MCA 3-6 Aircraft on the Traffic Circuit, from 11FEB2016.

1.20 Useful or effective investigation techniques.

With the support of a specialist in the analysis of causal nexus between vocal changes and occupational activity, active in the academic research area, a biometric identification of those involved was carried out by analyzing the parameters of voice, speech, language and variations in the characteristics of these parameters.

The use of this technique aimed to identify possible pre-existing conditions that could have affected the performance of the crew.

For analysis and comparison, audio files containing standard speech samples of the pilots and samples of their communication on the day of the occurrence were used.

As a result, this analysis concluded that the CM1 voice data pointed out discrepancies in speech and fluency patterns, which is compatible with cognitive-motor manifestations related, in the scientific literature, to fatigue states.

As for CM2, the findings for the acoustic and clinical parameters of speech and fluency showed signs of drowsiness throughout the flight path on the day of the incident.

2. ANALYSIS.

It was a return flight to the Santarém International Aerodrome (SBSN), departing from the Brasilia International Aerodrome (SBBR).

On the return to SBBR, during the first approach, the crew performed a go-around procedure, due to being destabilized in relation to the expected profile of approach and with the wind above the limit foreseen for landing. This procedure was correctly performed.

During the second approach, the crew was alerted, by both APP-BR and TWR-BR, that the weather conditions were adverse, with heavy rain on the airfield and a report of a slippery runway. The crew collated the information of conditions and proceeded with the approach.

Before analyzing the influence of weather conditions, it is important to note that, in several studies, including one published by Airbus, the aircraft manufacturer entitled: “Flight Operations Briefing Notes - Human Performance - Visual Illusions Awareness”, revision 2, from SEPT2005, both rain and low visibility can modify the crew's perception of references in the visual approach segment.

Thus, the meteorological conditions may have impaired the pilots' correct perception of the expected height for reducing the levers for IDLE and the beginning of FLARE.

It was observed that, in addition to the reports from the control agencies, the meteorological conditions were similar in the SPECI of SBBR, from 0836 (UTC):

> SPECI SBBR 300836Z 18010G22KT 140V230 0500 R11L/P2000 R29R/P2000 R11R/1300 R29L/P2000 +TSRA BKN005 FEW017CB 19/18 Q1015

This report showed that, in addition to the condition of heavy rain (+ TSRA), visibility of 2,000m (11L) and ceiling of 500 feet (BKN005), the presence of a strong wind component, with gusts up to 22kt and misaligned at 73º with the expected axis of approach to runway 11L, which was 107º (18010G22KT).

The data recorded in the SSFDR showed that the wind, at ten seconds of the touch was 154º / 22kt, varied in the direction of 181º with intensity of 25kt, thus revealing an extrapolation of the limits stipulated by the company's MGO for the operation of the Airbus fleet, with crosswind component on 18kt wet runway.

In this regard, it is also noteworthy that TWR-BR, when authorizing the landing on runway 11L, informed the following: “TAM 3081 the runway is free, landing authorized, I inform you that there was a report of a slippery runway, adjustment of one zero to one five, heavy rain.

As can be seen, the direction and intensity of the wind were not announced by the ATC, as prevised in MCA 3-6, Air Traffic Phraseology, of 11FEB2016, in force at the time of the occurrence. This information, if properly informed, could contribute to assist in the decision to proceed with a go-around procedure, if the wind limits were above those stipulated by the operator.

Although, at the time of the occurrence, the weather conditions on the airfield were degraded, technically they were still within the minimum required for the ILS CAT I operation, which prevised a minimum visibility of 700m and a ceiling of 300ft.

However, it is important to note that several risk factors for an approximation were present at the same time, mainly:

- lighting: the occurrence took place at a time very close to sunrise, about six minutes later, which corresponds to the sun in the direction of 112º and at an angle of 1 ° above the horizon line. In other words, the sun was in a direction very close to the approach axis of the runway (107º), which can cause a glare of the pilots, especially during the night-day transition. Another point is that the low height of the sun in relation to the horizon, associated with a layer of clouds at 500ft can make it difficult to adequately illuminate the field;

- rain: the presence of rain on the windshields modifies the pilots' perception in relation to height, lateral deviations and distances;

- wet runway: the presence of water on the runway alters the reflection of light, which affects the crew's perception of depth; and

- cross wind: due to the need for heading compensation, the greater the intensity and angle of the wind, the greater the inclination that the aircraft would have to maintain in relation to the runway axis, which contradicts the natural tendency of pilots to align the fuselage of the aircraft with the central axis of the runway.

Thus, it is possible to state that, although it was not decisive, the simultaneous association of all these risk factors contributed to the occurrence.

It should be noted that the aircraft was operating with inoperative A / THR, which was not an essential equipment for dispatching the aircraft, according to what was provided for in MEL 22-30-01A.

Despite not being considered an essential equipment for dispatching the aircraft, the non-use of the A / THR, as it is not a normal flight condition, required pilots to keep their focus on maintaining and correcting the approach speed of the aircraft, which, in a normal situation, would not require a high level of attention from the crew, only monitoring.

This demand was evident when it was observed that, during the second approach, between 1,000ft to 100ft RA, there were speed variations between 123kt (VAPP – 12kt) and 149kt (VAPP + 14kt), even though the autopilot was engaged.

As per the Airbus SOP Standard Callouts, Flight Parameters, the PM shall announce "SPEED" if the speed decreases below the speed target -5kt or increases above the speed target +10kt.

The speed variations recorded during the event were above the stabilisation criteria threshold. A go-around should have been considered by the crew.

The variations showed that the crew maintained the speed parameters, probably because they were executing the approach with strong crosswind and in adverse weather conditions.

According to the CM2, although he had undergone training for this type of situation (without A / THR), he felt uncomfortable, as he was not used to flying in this context. The two crewmembers reported feeling overwhelmed in the final operation, considering the condition of the aircraft and the meteorological scenario.

It is important to note that speed variations have always occurred from values between VAPP – 12kt and VAPP + 14kt, which indicated a basic and recommended piloting technique to compensate for strong winds associated with gusts, especially when operating on a long runway, as it was the case of the SBBR runway.

Several publications, among them the Quick Reference Handbook (QRH), brought the recommendation to increase the approach speed during approaches with strong winds, adding about 50% of the wind gust value.

As, during the final approach phase, wind speeds reached values around 25kt, an increase in approach speed around 12-13kt would be ideal, a value very close to the speed increase recorded by SSFDR, which was 14kt.

Thus, although technically the speed of 1-2kt above the recommended maximum sets up a destabilized approach, this factor would not compromise the landing, since the 3,200m length available on the runway was enough for a safe stop of the aircraft, even with this speeding.

Analyzing other data obtained from the flight recorders, it was observed that the aircraft, on the second approach, between 1,000ft and 100ft RA, was:

- below the MLW;

- with Slats, flaps, Ground spoilers, auto brakes and flight directors operational and properly configured;

- with a drift angle ranging from 6º to 9º, consistent with the presence of a strong cross wind;

- with a descent rate ranging between 440ft / min and 900ft / min, variation of approximately 200ft / min around the ratio calculated for the ILS Y RWY11L chart, which was 700ft / min to 130kt; and

- variations in the power levers of engines 1 and 2 with different TRA margins (6º to 11º in engine 1 and 8º to 14º in engine 2), consistent with the manual operation of the engines.

At the moment of decoupling the PA, at 100ft RA, until the moment of touch, the aircraft had:

- a gradual increase in the pitch angle from 1º to 5.2º, associated with the reduction of the descent rate from 700ft / min to around 100ft / min, consistent with the rounding maneuver for landing;

- the reduction of the levers to the IDLE position and the FLARE with approximately 80ft RA, considerably above the recommended in the company's FCTM, which was 30ft, which may have occurred due to a change in the perception of depth, by the crew, due to the weather conditions present. Such anticipation of FLARE allowed the aircraft to float on the runway, increasing the crosswind effect before the touch; and

- left pedal control, at about 30ft RA, in order to align the fuselage with the runway axis, followed by right pedal controls, associated with an increase of 10kt in the lateral wind component just before the touch. These data are consistent with the left lateral displacement of the aircraft during landing, which caused the tires of the left main landing gear to collide with four runway beacon lights, in addition to damage to four electrical boxes.

After the touch, the CM1 took back lateral control and returned the aircraft to the center of the runway axis. Then, there was a dialogue between the pilots of whether or not they had left the runway, both of whom declared doubts about what had happened.

This, again, denoted that the crew had a low situational awareness of the aircraft's position.

When considering the work context of the crew at the time of the occurrence, the roster had a schedule of consecutive days of flight, with presentations or awakenings at dawn, exceeding the company's internal rule that, if there are two sequential dawns, the schedules should be increasing and 48 hours of nighttime sleep should be offered.

It is worth mentioning that the company had a schedule optimizer system, CARMEN, and a biomathematical model, the BAM System, which interacted with the previous one to point out the limits and alert levels in relation to fatigue, in order to minimize adverse effects in operations.

The CARMEN System, when creating the schedule of the CM1, which went against the company’s rule of Dawn-Dawn-6h-8h, self-adjusted, anticipating the flight for the final half hour (23h35min) of the previous day, which made the most critical flight in relation to fatigue.

Although BAM pointed to the flight of the CM1 with a high level of fatigue, this was an acceptable level by the company, as it is still in the yellow range of the fatigue risk scale, even if in a borderline condition.

This highlights the fragility of the technological support used by the company, which allowed the extrapolation of internal rules, making the crew susceptible to flight situations that favored the reduction of the physical and mental performance capacity, as well as compromising the ability to perform the activities safely.

Although, at the time of the occurrence, the fatigue level (1014) of the CM1 was below the previous assessment of the entire flight schedule (1696) by BAM, the post-accident survey carried out by analyzing the voice parameters, speech and language identified

conditions compatible with a state of fatigue, in the scientific literature. Thus, there were pre-existing conditions that would be affecting the performance of the crew.

Despite the fact that the CM2 roster did not present a critical risk of fatigue, since it returned from rest, the copilot did not have adequate rest in the days before the flight. Consequently, the same post-accident survey showed signs of drowsiness throughout the flight path on the day of the occurrence. This state of drowsiness may also have compromised the crew's psychomotor performance.

Even though the company provided mechanisms for reporting and analyzing the risk of fatigue in the flight schedule, the crewmembers did not use them, either due to the influence of their personal characteristics and / or fear towards the organization.

Regardless of the reasons for the lack of reporting, this fact highlights the need for the company to review the incentive practices for the use of tools, when relevant.

In view of the above, the pre-existing flight conditions (individual, psychosocial and organizational) aligned with the conditions at the time of the occurrence (individual, operational and meteorological) favored a reduction in the level of crew performance.

The ICAO Doc 9966, 2016, pointed out that continuous / prolonged waking hours impact the individual's performance, reducing his alertness level and degrading his performance. It also shows that insufficient sleep affects cognitive functioning, with significant effects on information processing and response time and on the level of attention.

It is worth mentioning that the more the individual is restricted from the opportunity for restful sleep, which would avoid a situation of fatigue, the less is his ability to identify that his level of alertness and performance continue to decrease, that is, there is a difficulty in evaluating the functional condition itself.

Fatigue can significantly reduce the ability of flight crews to fly safely. Its effects include, among others, reduced monitoring, reduced mental ability to solve problems, reduced alertness and concentration, poor decision-making and fixation on a single task.

Thus, when analyzing the occurrence in the light of the theoretical foundations presented here, it was observed that the actions or failures in the actions taken by the crew were the result of the existing conditions.

Although the crew successfully performed the procedures for missed approach on the first attempt, it is plausible that the performance deteriorated further on the second attempt, when they proceeded to land even with the deterioration of weather conditions.

Landing, on its own, is considered one of the most critical phases of the flight. This fact, combined with the operational situation of the aircraft, which required an unusual procedure; the conditions of the crew (tired / fatigued); and the weather conditions existing at the time, made the crew susceptible to flaws in the decision-making process, in the perception and judgment of piloting. Since they did not evaluate how the circumstances could affect the operation, even having considered the possibility of alternating, the pilots performed the landing at the destination initially programmed; not being able to perceive and react in a timely manner, at the moment the aircraft was taken to exceed the lateral limits of the runway.

3. CONCLUSIONS.

3.1 Facts.

a) the pilots had valid CMAs;

b) the pilots had valid A320 aircraft type Rating (which included the A320-232 model) and IFRA Ratings;

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 aircraft was with the A / THR OFF;

h) meteorological conditions simultaneously associated several risk factors for the approach;

i) there was a strong wind, with a side component of up to 20kt;

j) Schedule Planning did not consider the rules prevised in the Aeronaut Law and in the Collective Agreements and Conventions;

k) the flight schedule of the crew was susceptible to fatigue during the period of the occurrence;

l) the roster had a schedule of consecutive days of flight, with presentations or waking up at dawn, exceeding the company's internal rules;

m) fatigue was reported by the crew during the beginning of the flight schedule briefing;

n) the final approach was performed with a drift angle varying between 6º and 9º;

o) FLARE was carried out above the height provided for in the EA Operations Manual;

p) damage occurred to four beacon lights and four boxes of electrical passage on runway 11L;

q) the crewmembers were in doubt as to whether the aircraft left the runway or not;

r) the aircraft had substantial damage; and

s) s) all occupants left unharmed.

3.2 Contributing factors.

- **Control skills – a contributor.**

The reduction of the thrust levers to the IDLE position and the FLARE with approximately 80ft RA, associated with an inadequate rudder and aileron control contributed to the runway excursion.

- **Attention – undetermined.**

Given the scenario of the occurrence, there is a possibility that the level of attention required from the crew for the operation to be compromised, making it difficult to maintain good performance in a flight situation that required a higher degree of this executive function to act appropriately in the face of speed variation.

- **Training – undetermined.**

Although the flight condition without A / THR is part of the company's operational training, it is possible that the frequency with which it was officially performed by the crew did not guarantee safety in the execution of the procedure in a real flight, given the feeling of discomfort experienced by part of the crew.

- **Adverse meteorological conditions – undetermined.**

At the time of the occurrence, the weather conditions on the airfield were degraded, which may have contributed to the inappropriate judgment of the reduction of the thrust levers for IDLE and the beginning of FLARE with approximately 80ft RA.

- **Emotional state – undetermined.**

The feeling of discomfort with the aircraft configuration, reported by the crew, combined with the final context of the flight (weather degradation and missed approach), which increased the workload level, may have interfered with the crew's performance to the point of not assimilating correctly how circumstances could affect the operation.

- **Fatigue – undetermined.**

The conditions of susceptibility to fatigue present in the occurrence, associated with the degradation of performance demonstrated by the crew, denoted the possibility of a fatigue situation that impacted the crew's ability to assess and respond promptly to the work demands required to achieve a successful landing.

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

On the second approach, at the time of landing authorization, data related to the direction and intensity of the wind were not included in the message passed by the TWR-BR. This information could contribute to assist in the decision to proceed with a possible go-around procedure, if the crew evaluated the extrapolation of the limits established by the company.

- **Piloting judgment – a contributor.**

The reduction of the thrust levers to IDLE and the start of FLARE with approximately 80ft RA indicated an inadequate assessment by the pilot of parameters related to the operation of the aircraft.

- **Work organization – a contributor.**

The company's schedule planning adopted for the period of the occurrence, a critical flight roster for the crew, in relation to fatigue, which favored a lowering of the level of physical and mental performance, putting at risk the ability to perform the operational activity safely.

- **Perception – a contributor.**

It was possible to observe a lowering of the crew's situational awareness level, since after landing they had no precision as to whether or not they left the runway. Such demotion is possible in view of the work context to which they were subjected during the flight of the occurrence.

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

The decision to proceed to the landing, on the second approach, in which there was a deterioration of meteorological conditions, showed an inaccurate assessment of the circumstances that would affect the operation, culminating in an off-axis landing.

It is worth mentioning that the lack of adequate rest is one of the factors that compromises the ability to solve problems and make appropriate decisions.

- **Support systems – a contributor.**

The technological support used by the company for flight scheduling allowed the extrapolation of internal rules, which aimed at more appropriate working hours, thus exposing crewmembers to situations that favored the degradation of their performance, both physical and mental.

The fatigue risk reporting mechanism offered by the company to its crewmembers, in this case, was not used, suggesting, still, the existence of flaws in its implementation and sedimentation process.

- **Other – undetermined.**

Influence of the environment: the position of the sun in relation to the horizon, making it difficult to adequately illuminate the field, associated with a cloud layer at 500ft, may have caused a glare of the pilots during the final approach phase for landing.

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-155/CENIPA/2017 - 01 **Issued on 29/03/2021**

Work with LATAM AIRLINES GROUP S.A, so that operator reassesses the suitability of the training program applied to its pilots, especially with regard to the frequency and control of landing training without the Auto Thrust - Automatic Thrust Control (A / THR).

IG-155/CENIPA/2017 - 02 **Issued on 29/03/2021**

Work with LATAM AIRLINES GROUP S.A, so that operator reassesses the suitability of the CARMEN schedule optimizer system and the BAM biomathematical model, especially with regard to the mechanisms of protection and alert against fatigue, in order to minimize adverse effects on the company's operations.

To the Airspace Control Department (DECEA):

IG-155/CENIPA/2017 - 03 **Issued on 29/03/2021**

Work with Air Traffic Services (ATS) personnel to ratify compliance with the air traffic phraseology standards contained in the MCA 100-16, currently in force, in order to ensure the uniformity of radio communications.

5. CORRECTIVE OR PREVENTATIVE ACTION ALREADY TAKEN.

None.

On March 29th, 2021.