COMANDO DA AERONÁUTICA

CENTRO DE INVESTIGAÇÃO E PREVENÇÃO DE ACIDENTES AERONÁUTICOS

FINAL REPORT
A-093/CENIPA/2020

OCCURRENCE:	**ACCIDENT**
AIRCRAFT:	**PR-MJX**
MODEL:	**AS-350 B2**
DATE:	**30JUL2020**

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 considering 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 distinct 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 Final Report has been made available to the ANAC and the DECEA so that the technical-scientific analyses of this investigation can be used as a source of data and information, aiming at identifying hazards and assessing risks, as set forth in the Brazilian Program for Civil Aviation Operational Safety (PSO-BR).

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. Considering 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 30 July 2020 accident involving the model AS-350 B2 aircraft of registration marks PR-MJX. The occurrence was typified as “[CFIT] Controlled flight into terrain”.

During the final approach for landing in a college parking lot, the main rotor blades of the helicopter collided with the facade of a building.

The aircraft sustained substantial damage.

The occupants of the aircraft were slightly injured.

Being France the State of aircraft manufacture, the French *Bureau d'Enquêtes et d'Analyses pour la Sécurité de l'Aviation Civile* (BEA) designated an Accredited Representative for participation in the investigation of the accident.

TABLE OF CONTENTS

GLOSSARY OF TECHNICAL TERMS AND ABBREVIATIONS

ABNT	Brazilian Association of Technical Standards
ADE	Registry Category for Aircraft under direct State administration
AFM	*Aircraft Flight Manual*
ANAC	Brazil's National Civil Aviation Agency
BEA	*Bureau d'Enquêtes et d'Analyses pour la Sécurité de l'Aviation Civile* (France)
CBMDF	Federal District's Military Fire Department
CBMSC	*Santa Catarina* State's Military Fire Department
CENIPA	Brazil's Aeronautical Accidents Investigation and Prevention Center
CG	Center of Gravity
CMA	Aeronautical Medical Certificate
CRM/TRM	Crew Resource Management
CVA	Certificate of Airworthiness Verification
ESAV	Aviation Squad
GAVOP	Operational Aviation Unit
HRM	Hover Reference Markers
MCA	Command of Aeronautics' Manual
MEL	Minimum Equipment List
METAR	Routine Meteorological Aerodrome Report
MGSO	Safety Management Manual
MOP	Operations Manual
NATO	North Atlantic Treaty Organization
PCH	Commercial Pilot License - Helicóptero
PCR	Cardiopulmonary arrest (CPA)
PIC	Pilot in Command
PMD	Maximum Takeoff Weight (MTOW)
POB	Persons on board
POP	Standard Operating Procedures
PPH	Private Pilot License - Helicopter
RBAC	Brazilian Civil Aviation Regulation
RIDE-DF	Integrated Development Region of the Federal District and Metropolitan Area
RTO	*Research and Technology Organisation*
SBBR	ICAO location designator – *Brasília* (*Presidente Juscelino Kubitschek*) International Airport

SBFZ	ICAO location designator – *Fortaleza* (*Pinto Martins*) International Airport, State of *Ceará*
SBMK	ICAO location designator - *Mario Ribeiro* Airport, *Montes Claros*, State of *Minas Gerais*
SERIPA	Regional Service for the Investigation and Prevention of Aeronautical Accidents
SGSO	Safety Management System (SMS)
SIC	Pilot Second in Command
SIPAER	Aeronautical Accidents Investigation and Prevention System
SOP	Standard Operating Procedures
SN	Serial Number
SPECI	Aviation Selected Special Weather Report
UAP	Public Air Unit
UTC	Coordinated Universal Time
VFR	Visual Flight Rules
ZPH	Helicopter Landing Zone

1. FACTUAL INFORMATION.

Aircraft	**Model:** AS-350 B2 **Registration:** PR-MJX **Manufacturer:** HELIBRAS	**Operator:** *Corpo de Bombeiros Militar do Distrito Federal (CBMDF)*
Occurrence	**Date/time**: 30JUL2020 – 14:30 (UTC) **Location:** *Região Administrativa de Vicente Pires* **Lat.** 15°49’11”S **Long.** 048°01’19”W **Municipality – State:** *Brasília – Distrito Federal.*	**Type(s):** [CFIT] Controlled flight into or toward terrain

1.1. History of the flight.

The aircraft took off from the Helipad of the Operational Aviation Group (*GAVOP*) of the *CBMDF*, *Brasília*, Federal District (*DF*), bound for an unregistered landing area located in the Administrative Region of *Vicente Pires*, *DF*, in order to provide initial aid to a victim of cardiopulmonary arrest (CPA), with 05 POB (crew members).

During the final approach for landing at the college parking lot, the helicopter’s main rotor blades collided with the facade of a building.

Figure 1 - View of the PR-MJX at the accident site.

The aircraft sustained substantial damage, whereas the crew suffered minor injuries.

1.2. Injuries to persons.

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

1.3. Damage to the aircraft.

The aircraft sustained substantial widespread damage.

1.4. Other damage.

There was damage to a vehicle parked at the site, to the facade of the college building, and to a window of another building located near the accident site (Figures 2, 3 and 4).

Figure 2 - Damage to the facade of the building.

Figure 3 - Damage to a vehicle caused by the helicopter's skid.

Figure 4 - Windowpane of a nearby building broken by debris.

1.5. Personnel information.

1.5.1. Crew's flight experience.

Flight Experience		
	PIC	SIC
Total	883:55	432:25
Total in the last 30 days	05:00	04:45
Total in the last 24 hours	00:15	00:15
In this type of aircraft	508:20	232:15
In this type in the last 30 days	05:00	04:45
In this type in the last 24 hours	00:15	00:15

RMK: data provided by the Operations Section of the Operational Aviation Group.

1.5.2. Personnel training.

The PIC and the SIC did their PPH Courses (Private Pilot - Helicopter), at *EDRA Aeronáutica*, *São Paulo*, State of *São Paulo*, in 2007 and 2013, respectively.

1.5.3. Category of licenses and validity of certificates.

The PIC held a PCH License (Commercial Pilot - Helicopter) and had a valid rating for HMNT (Single-Engine Turbine Helicopter).

The pilot Second-in-Command (SIC) held a PPH license and a valid HMNT rating.

1.5.4. Qualification and flight experience.

Both pilots were qualified and experienced in the type of flight.

1.5.5. Validity of medical certificate.

The pilots held valid CMAs (Aeronautical Medical Certificates).

1.6. Aircraft information.

The SN 4254 aircraft, model AS-350 B2, was a product manufactured by HELIBRAS in 2007, and registered in the *ADE* Category (Direct State-Administration Registry).

The *PMD* (Maximum Takeoff Weight) of the helicopter was 2,250 kg.

The helicopter's CVA (Airworthiness-Verification Certificate) was valid.

The records of the airframe and engine logbooks were up to date.

The latest inspection of the aircraft ("100-hour" type) was carried out on 08 June 2020 by *Helistar Manutenção de Aeronaves Ltda*. maintenance organization (COM 1202-61/ANAC). The aircraft flew 62 hours and 50 minutes after the referred inspection.

No evidence was found of failures or malfunctions of the aircraft or its components that might have contributed to the occurrence.

In accordance with the AS350's Flight Manual, Section 7.1, page 1, the aircraft had the following dimensions, as shown in Figure 5.

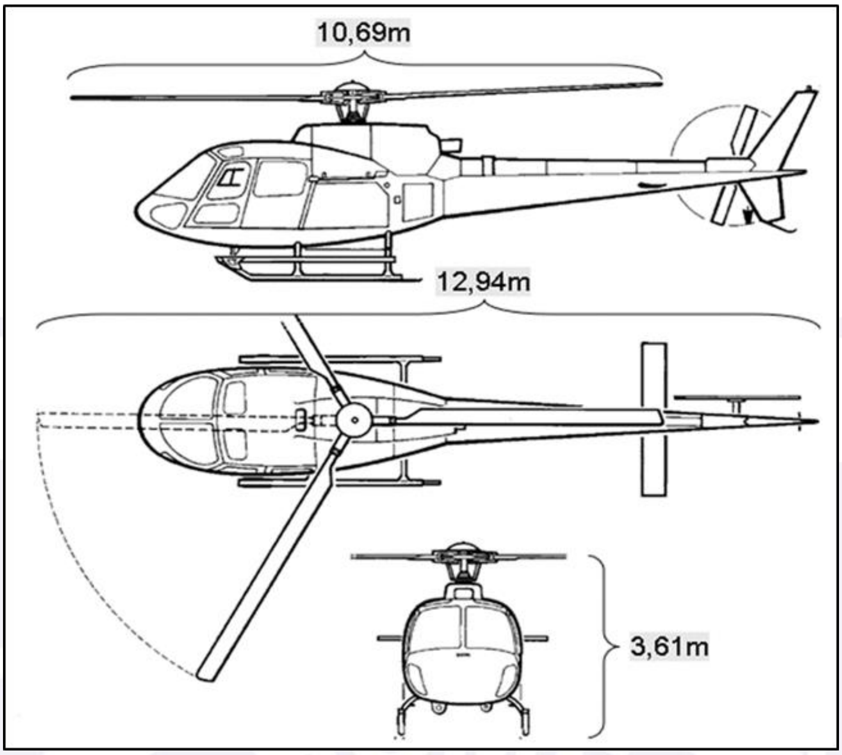

Figure 5 - Basic dimensions of the AS-350 B2.

1.7. Meteorological information.

The weather conditions were consistent with VFR flights.

The routine Meteorological Aerodrome Report (METAR) and the Aviation Selected Special Weather Report (SPECI) of *Presidente Juscelino Kubitschek* Aerodrome (SBBR), located at a distance of 6.5 NM from the accident site, contained the following information:

METAR SBBR 301400Z 10013KT CAVOK 07/26 Q1024=

SPECI SBBR 301420Z 08011G21KT CAVOK 06/27 Q1024=

According to reports from the pilots and ground crew, the prevailing wind at the landing site crossed from left to right with low intensity.

The dry season in the Federal District had started on 19 May 2020. Thus, it had not rained for at least 73 days at the accident site.

1.8. Aids to navigation.

NIL.

1.9. Communications.

NIL.

1.10. Aerodrome information.

The accident of the aircraft occurred far from any aerodrome.

The parking lot used for the occasional landing had a rectangular shape measuring approximately 28.5 m x 74.3 m.

There was a small set of bleachers on the right-hand side of the parking lot, reducing the lateral dimension of the area to 25.6 m.

The surface of the landing area was made of concrete. However, there was a lot of accumulated dust and debris - consisting of small pieces of concrete, sand and gravel - due to the prolonged period of drought in the Federal District and due to the degradation of the parking lot pavement (Figure 6).

Figure 6 - Condition of the landing area surface.

The area selected for the landing was surrounded by the obstacles identified in Figure 7.

Figure 7 - Obstacles located in the landing area.
Source: adapted from Google Maps.

Figure 8 highlights the fence, the small set of bleachers, and the restaurant, which were all located on the sides of the landing area.

Figure 8 - Detail of the obstacles located in the landing area.

The buildings located around the occasional landing area made it difficult to disperse the dust raised by the downwash of the helicopter's main rotor.

1.11. Flight recorders.

Neither required nor fitted.

1.12. Wreckage and impact information.

The impact occurred on the approach for landing in the college parking lot, when the aircraft's main rotor blades collided with the facade of a building located to the left of the landing area (Figures 9 and 10).

Figure 9 - Sequence of the collision of the PR-MJX with the college building.

The wreckage ended up concentrating near the building struck by the aircraft (Figure 10).

Figure 10 - Location of the concentration of the aircraft wreckage.

During the Initial Action of the investigation, one verified that the building was approximately 9.35 m tall, and that the collision occurred near the top of the building.

There was no separation of parts of the aircraft before the impact with the building.

1.13. Medical and pathological information.

1.13.1. Medical aspects.

There was no evidence that issues of physiological nature might have affected the crew's performance.

1.13.2. Ergonomic information.

NIL.

1.13.3. Psychological aspects.

No evidence was found that psychological issues might have affected the crew's performance.

1.14. Fire.

There was no fire.

1.15. Survival aspects.

NIL.

1.16. Tests and research.

NIL.

1.17. Organizational and management information.

On 11 April 2019, the ANAC published the Resolution nº 512 - Amendment nº 00, approving the Brazilian Civil Aviation Regulation nº 90 (RBAC-90), dealing with "Requirements for special public aviation operations".

According to Art. 2 of the Resolution, the following transitional provisions should be applied to the RBAC-90, Amendment No. 00:

> [...]
>
> V - the stages of the MOP implementation plan are to take place within the following deadlines:
>
> a) by 12 April 2020, for the preparation of the MOP;
>
> b) by 12 July 2020, for the approval of the MOP by the UAP manager;
>
> c) by 12 October 2020, for the dissemination of the content of the MOP to those involved in the UAP's air operations; and
>
> d) by 12 April 2021, for the implementation of all procedures and policies defined in the MOP by the UAP;
>
> VI - the stages of the SOP implementation plan must be implemented within the following deadlines:
>
> a) by 12 April 2020, for the preparation of the SOP;
>
> b) by 12 July 2020, for the approval of the SOP by the UAP manager;
>
> c) by 12 October 2020, for the dissemination of the SOP content to those involved in UAP air operations; and
>
> d) by 12 April 2021, for the implementation of all procedures and policies defined in the SOP by the UAP;
>
> VII - public agencies and entities must comply with the provisions of Subpart K of the RBAC-90 as of 12 April 2020;
>
> VIII - public bodies and entities will have the deadline of 12 July 2020 to comply with the provisions of Subpart M of RBAC-90, with permission to use training programs approved according to Subpart K of RBHA 91 during the validity of this transitional provision;
>
> [...]

Thus, among other Subparts, the RBAC was composed of the following ones:

> [...]
>
> SUBPART H - UAP MANUALS' SYSTEM
>
> 90.101 General Requirements
>
> SUBPART I - MANUAL OF OPERATIONS (MOP)
>
> 90.111 General Requirements

SUBPART J - STANDARD OPERATING PROCEDURES

90.121 General Requirements

SUBPART K - SAFETY MANAGEMENT SYSTEM

90.131 General Requirements

90.133 Structure

90.135 Component 1 - operational safety policy and objectives

90.137 Component 2 - operational safety risk management

90.139 Component 3 - operational safety assurance

90.141 Component 4 - operational safety promotion.

[...]

With respect to section 90.101 - *General Requirements* - of Subpart H, the system of manuals of the Public Air Unit (*UAP*) should consist of the following publications:

(1) MOP, according to subpart I of this Regulation;

(2) training program;

(3) SOP, according to subpart J of this Regulation;

(4) MGSO, according to subpart K of this Regulation;

(5) MEL, if applicable, according to section 90.87 of this Regulation; and

(6) other manuals and publications at the discretion of the UAP.

In turn, the section 90.111 - *General requirements* - of Subpart I, the Operations Manual (MOP) should:

(1) be a standardization mechanism for achieving the UAP's operational safety performance;

(2) be approved by the UAP manager;

(3) provide detailed instructions for the UAP's activities, with guidelines related to operational safety;

(4) be applied consistently and uniformly within the UAP;

(5) encourage the reporting of discrepancies, improvements, updates, best practices for the implementation and review of this publication;

(6) be integrated into the SGSO of the public agency or entity; and

(7) be used during training.

(b) Actions or operations provided for in other UAP publications may be included in a MOP.

(c) The content of the MOP must take into account the operational specificities, attributions of the public agency or entity, the type of personnel involved and the characteristics of the UAP fleet.

(d) The MOP must be reviewed by the UAP whenever necessary, even after its implementation, to preserve the operational safety performance of the relevant UAP.

In turn, the section 90.121 *General requirements* of Subpart J, *Standard Operating Procedures* (*POP*) established that they should:

[...]

(1) be a standardization mechanism for achieving the operational safety performance of the UAP;

(2) be approved by the UAP manager;

(3) be prepared in accordance with the aircraft model when there are significant differences in the operation of the various models in the UAP fleet, regardless of the qualification required to piloting them. However, in order to maintain a single operational philosophy, the differences between the SOPs for each aircraft model

should be limited to the differences and specificities of each model, facilitating the transition of crew members (or other people with functions on board) between the models in question;

(4) be a formal, clear and comprehensive publication covering routine UAP activities and aiming to establish an appropriate standard for the performance of tasks in a safe, organized, coherent and sustainable manner;

(5) be kept on board the aircraft for consultation by crew members and other people with functions on board;

(6) be based on central CRM concepts that aim at effective cabin coordination, associated with the performance of the crew and other people with a role on board for the activities related to each function;

(7) guide crew members and other people with a role on board regarding operations, in all phases of flight, in a safe, efficient, logical, and predictable manner;

(8) cover normal, abnormal, and emergency procedures;

(9) compose the UAP training program;

(10) provide detailed instructions on the activity to be performed, in addition to presenting operational safety guidelines;

(11) establish practical and appropriate procedures for each situation/operation;

(12) provide a consistent and standardized mental model of each task that will be performed by crew members and people with a role on board during each phase of flight and during any reasonably foreseeable emergency situation;

(13) describe parameters for the carry-out of activities, defining the duties of each crew member and person on board and for each role (pilot flying, pilot monitoring, pilot in command, pilot second in command), in each phase of the flight, with criteria for choosing between the different possible procedures, if any;

(14) reflect the standard operation of the UAP, as well as its day-to-day activities, and its use should not be limited to training, assessments, proficiency and/or observation exams;

(15) be applied consistently and uniformly within the UAP;

(16) contain detailed descriptions and/or pictorial posters of the applicable maneuvers;

(17) be written in a concise, step-by-step manner that is easy to read and understand. The information should avoid ambiguity. Active voice and verbs in the infinitive should be used. The information should be clear and explicit, so that there is no uncertainty when applied;

(18) present procedures preferably in sequence, with a new action starting only after the completion of the preceding action;

(19) be written in Portuguese. If the organization presents the SOP, or parts thereof, in English, the UAP must ensure that the personnel involved in the publication are proficient in the language in question;

(20) establish a routine so that these procedures are always updated in accordance with the AFM, checklists, bulletins, reports, and guidelines issued by the manufacturer or aviation authorities;

21) be constantly evaluated and reviewed by the UAP crew members, as well as by people with functions on board;

(22) encourage its crew members and people with functions on board to report discrepancies, improvements, updates, best practices for the implementation and review of this publication;

(23) be integrated into the SGSO of the public agency or entity. The SOP revisions should ideally be discussed in CSO meetings, in order to verify their impact on the safety of operations. In addition, the SOP revisions may be proposed as a way to mitigate risks detected by the public agency or entity;

(24) be available in the aircraft cockpit or workplace of the professional involved in the operation;

(25) be prepared with the participation of UAP professionals, as applicable;

(26) provide, to the crew members and people with functions on board, general guidelines for conducting briefings, in addition to the content to be addressed; and

(27) observe other aspects deemed relevant by the UAP.

The missions carried out by the *CBMDF*'s *GAVOP* fit into this scenario.

The *GAVOP* was a UAP responsible for performing the air activities related to the various missions performed by the *CBMDF*, and had the following responsibilities:

I - to perform the specialized operational aviation activities;

II - to promote the continued training of personnel allocated to the squads;

III - to assess the demand for materials and equipment from subordinate Units, forwarding it monthly to the higher echelon;

IV - to distribute the materials and equipment used for operational aviation activities to the squads;

V - to ensure compliance with the aeronautical legislation;

VI - to advise the higher echelons on compliance with the safety recommendations issued to the *CBMDF* by the competent bodies, as a result of the investigation of an aeronautical accident or incident and of the completion of flight safety inspections;

VII - to perform, in accordance with the specific legislation, aircraft maintenance services, by its own means or by means of third parties;

VIII - provide the necessary support to the entities responsible for preventing and investigating aircraft accidents, when requested.

However, the pre-hospital care, as the main occurrence dealt with by the *CBMDF* aircraft fleet, was based on the Emergency and Urgency System published in the Ministry of Health’s Ordinance nº 2048, dated 05 November 2002.

In the referred document, the primary mobile pre-hospital care was defined as a request for help made by a citizen, while the secondary mobile pre-hospital care referred to a request made by a health service, in which it would be necessary to transport the patient to another unit of greater complexity for continuity of treatment.

The *CBMDF*’s *GAVOP* would allocate aircraft and crews according to the type of mission, and was composed of two Aviation Squads (ESAV): one utilizing rotary wing aircraft, and the other one utilizing fixed wing aircraft. Both squads had norms, published in the *CBMDF*’s general bulletins, which regulated the operation.

The *GAVOP* had two published documents regarding the activation of rotary wing aircraft:

- Ordinance nº 60 of 14 November 2002, General Bulletin nº 216 of 18 November 2002 - Criteria for the activation of rotary wing aircraft; and
- General Bulletin nº 082 of 02 MAY 2012, LII - Criteria for immediate activation of rotary wing aircraft of the *CBMDF*.

The immediate activation of *GAVOP* aircraft took into account two main factors:

- <u>Time Factor</u>

a. Accidents in locations more than 30 km away from trauma reference hospitals, especially on the highways of main access to the Federal District (BR-010, BR-020, BR-040, BR-060, BR-070, BR-080, and BR-251 highways); and

b. Accidents in locations in which the travel time from the scene of the occurrence to the reference hospital, depending on the traffic conditions, would take more than 15 minutes.

- Situational Factor

a. Possible existence of more than four victims;

b. Drownings; and

c. Forest fires in the priority conservation-units listed below:

• *Águas Emendadas* Ecological Station;

• *IBGE* Ecological Reserve;

• *Brasília* National Park;

• *Brasília* Botanical Garden;

• *Granja do Torto* Official Residence;

• *Fazenda Água Limpa* – FAL / UnB;

• National Forest;

• Vicinity of *Brasília* International Airport; and

• *Chapada Imperial*.

The coordination of the various aircraft assisting occurrences and disasters was performed by the very members of the *CBMDF*, in accordance with the principles of the Incident Command System.

The travel time depended on the location and could be effected at any point within the Integrated Development Region of the Federal District and Surrounding Area (*RIDE*). The *RIDE* covered a large number of municipalities in the Federal District, State of *Goiás*, and State of *Minas Gerais*. These pertinent municipalities were part of an area of common planning and public policy generation, for purposes of fostering the development of their population.

According to the *CBMDF's* Operational Deployment Plan, the phases of the assistance provided would be established according to the following major actions:

a. Notification/Activation;

b. Start-up;

c. Travel

d. Reconnaissance;

e. Planning;

f. Establishment;

g. Operation (Rescue Actions);

h. Control;

i. Final Inspection/Aftermath; and

j. Demobilization/Return.

Among the phases presented above, the *GAVOP*'s Manual established the following procedures for the air rescue phase with rotary wing aircraft:

[...]

e. Reconnaissance and landing: the crew visualizes the occurrence as a whole and defines the best procedure to be carried out to provide air support without compromising the safety of the flight and of the rescue teams. The site is analyzed, before approach and landing. The co-pilot coordinates with the ground teams the support for isolation of the landing site.

[...]

Among other prevention tools, the *GAVOP's* Safety Management Manual (MGSO), in item 4 - "Specific Prevention Programs", established the following ones:

> **a. Operational Risk Management**: it is the process of identifying hazards, their consequences, assessing their implications (risks), so as to decide on a course of action and evaluation of the results. Its purpose is to guide the balanced allocation of an organization's human and material resources, aiming at risk control and mitigation.
>
> **b. Crew Resource Management** (CRM/TRM): it is a training tool that, through theoretical and practical activities, aims to work with the attitudes and, consequently, the behaviors of airmen, aiming at the safety of air operations.
>
> [...]
>
> **d. Prevention of CFIT (Controlled Flight into Terrain)**: an occurrence in which an aircraft, in fully controlled flight conditions, collides with the ground, water or obstacle, without the crew being aware of the fact. The most remarkable characteristic of a CFIT is the fact that the flight period preceding the collision develops in a fully controlled manner.

The Manual also included, in its Chapter IV - *General Air Traffic Rules*, the following definitions and procedures related to the Helicopter Landing Zone (*ZPH*).

> A helicopter landing zone is any area, whether approved or not, intended for landing and takeoff operations of rotary wing aircraft. Unapproved occasional landing sites are covered by the RBAC-90, which exempts the *CBMDF* from the requirements established for registered and approved landings and takeoffs for the type of aircraft involved and for the operation proposed by the regulation.
>
> Ordinances or other regulations do not define the measures for occasional or emergency landing areas. Therefore, it is up to the crew to define the area according to the group's knowledge and to the limitations of the occurrence.
>
> The definition of the landing site and the establishment of a *ZPH* depend mainly on the following aspects related to safety:
>
> • Dimensions of the touchdown area (17 meters X 17 meters);
>
> • The area must be completely clear;
>
> • Topography of the terrain (flat and level);
>
> • Characteristics of the soil and/or vegetation in the touchdown area (soil compatible with the weight of the aircraft, low vegetation);
>
> • Proximity to vulnerable areas (shacks, debris, flooded areas, sand);
>
> • Ease of isolation (resources necessary to ensure the safety and isolation of the area).
>
> As a general rule, a *ZPH* will only be established when the following aspects are ensured:
>
> • Technical feasibility for landing and subsequent take-off; and
>
> • The safety of the crew, of the aircraft, of the personnel involved in the event, and of the general public in the vicinity of the event.

For the utilization of a *ZPH* in an urban area, the manual recommended observation of the following points:

> *ZPH* IN AN URBAN AREA
>
> For the creation of a *ZPH* in urban areas, the following points should be considered:
>
> • to observe all the guidelines regarding the safety of the location recommended by the *CBMDF*;
>
> • to avoid establishing the *ZPH* too close to the location of the main event. This increases the risk of accidents and hinders the work of the teams. To establish the *ZPH* at a distance of approximately 50 meters from the event, as shown in the figure below;

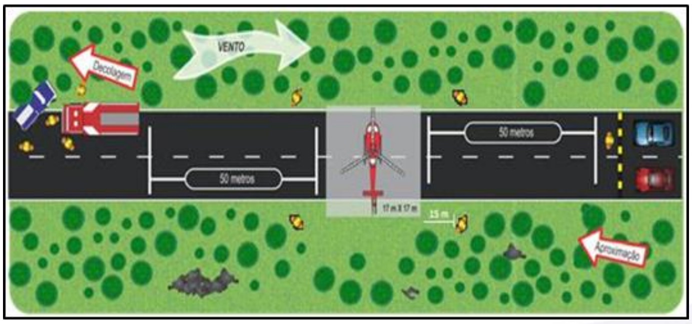

Figure 11 - Establishing a ZPH on a highway.

• In road accidents, prioritize landing in the center of the road. The flow of vehicles should be blocked in both directions at a distance compatible with the speed of the road (minimum of 50 m);

• Land on the central or side medians of highways, provided that all items for the establishment are observed;

<u>In areas with sandy or muddy terrain and if a vehicle with water is available, prepare the landing area by wetting the landing point to prevent dust from affecting the landing of the aircraft, thus compromising the safety of the operation</u> (emphasis added);

• Avoid landing areas near curves. Always consider the risk of cars colliding with the aircraft;

• Whenever possible, the approach and take-off ramps should be free of significant obstacles;

• Have a military person on the radio to ensure effective exchange of information between ground rescue and the aircraft crew;

• If necessary, and in advance, inform the aircraft crew about the presence of other aircraft and birds, especially vultures, in the vicinity of the operation site;

• Distribute the staff around the touchdown area, which is the part of the landing/take-off area, with defined dimensions, where the helicopter should touch down when landing;

• Observe the existence of wiring crossing the highway near the touchdown area. If applicable, alert the aircraft crew via radio;

• Keep everyone, including those individuals directly involved in the incident, away from the touchdown area at the time of landing. The minimum distance is 15 meters beyond the ZPH;

• pay extra attention to the presence of children and animals near the incident area;

• A military person may guide the landing at the ZPH. This procedure makes it easier to define the approach ramp and demonstrates that there are staff members capable of providing the necessary safety at the location;

• If it is nighttime, keep the vehicles with the lights on and headlights on at all times. Note, however, that the headlights can dazzle the vision of the pilots and operational crew.

For the use of a ZPH in a non-urban area, the manual recommended that the points described below be observed:

ZPH IN NON-URBAN AREAS

• In events in non-urban areas, where it is necessary to create a ZPH, the same dimensions are observed (17m X 17m);

• keep the touchdown area completely clear. There should be no obstacles of any kind that could pose a risk to the helicopter's structure, e.g., landing gear, tail rotor, searchlight and aircraft hook;

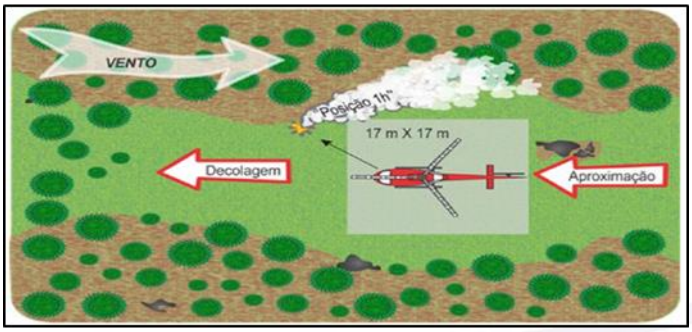

Figure 12 - Establishment of a *ZPH* in a rural area.

The branches and trunks of the cut vegetation should be thrown in stipulated areas and approximately 5 meters outside the *ZPH*;

• Whenever possible, the approach and take-off ramps should be free of significant obstacles. Pruning the tallest trees located on the ramps is a solution;

• Use fire to produce smoke and, by means of that, indicate the location of the *ZPH*, as well as the direction and intensity of the wind. The bonfire should be made approximately 15 meters outside the ZPH area and there should be a firebreak;

• The bonfire is not essential for the operation and, when prepared, it shall be positioned in the upper right part of the *ZPH*, and, in dry weather, vegetation must be watched so as to avoid causing forest fires;

• A military person may guide the landing in the *ZPH*. This procedure facilitates the definition of the approach ramp and demonstrates that there are staff members capable of providing the necessary safety support;

• During landing, a large amount of solid particles will be lifted in the air.

[…]

The Chapter IV of the manual, item 1. *Aircraft Crew*, contained the following considerations:

1. AIRCRAFT CREW

Pilots (PIL), operational crew members (TOp) and physicians (DOC) are the professionals who actively participate in cabin communication involving landing and takeoff procedures in operational missions. The 1P will be in command of the aircraft, the 2P will be the copilot, the TOP1 or TOP3 will be at the right door and the TOP2 or DOC will be at the left door. The TOP3 will be the launch crew member in missions that require boarding and disembarking in the hover by means any of the techniques eventually recommended.

If there is another individual or professional on board, he or she may participate in the communication as long as the information to be passed on is relevant to the flight. The standardization described in this chapter must be used to warn, for example, about the position of objects that may collide with the aircraft during the flight.

1.18. Operational information.

The aircraft was within the limits of weight and center of gravity (CG) specified by the manufacturer.

At approximately 08:00 local time on the day of the accident, according to reports from the pilots, a briefing was held with the crew on duty, in which they were reminded of both normal and emergency procedures for rescue missions with rotary wing aircraft.

After assuming their duty, both pilots went to their work sectors, and remained there until the flight was activated.

At about 10:10 local time, the crew was summoned by radio to provide support to a CPA victim in the administrative region of *Vicente Pires*, Federal District, and to take them to a hospital unit.

The SIC was informed of the address and coordinates of the emergency site, verified the nature of the occurrence, requested the ground team to assist with the landing, and headed for the designated aircraft.

In VMC, the aircraft took from the *GAVOP* Helipad towards Brasília International Racetrack. After takeoff, the SIC took over the flight controls, and flew the aircraft to the rescue site.

It took the aircraft approximately 5 minutes to fly the distance to the landing area.

The PIC subsequently took control of the aircraft and flew over the region for 5 minutes, analyzing the prospective landing sites and awaiting the arrival of the ground team.

In coordination with the helicopter, a vehicle carrying the ground team drove to *Mauá* College yard, a location already used for occasional landings. Then, the military personnel, from the ground, guided the approach of the aircraft.

The PIC performed two orbits to verify the landing conditions, such as: prevailing wind, type of surface, and obstacles. After evaluating the factors that could interfere with a safe landing, he chose to head north, as it was considered the best alternative for a go-around. The landing procedure was then initiated, with the pilot utilizing a high-angle approach.

From that moment on, the maneuvers that preceded the accident were extensively recorded on video by observers who were near the intended landing area.

The sequence of the PR-MJX's approach to landing is shown in Figures 13 and 15.

Figure 13 - Initial segment of the PR-MJX's approach.

Figure 14 - View of the PR-MJX's approach.

Figure 15 - Right-hand side view of the PR-MJX's approach.

Figure 16 shows the helicopter crossing the line of the buildings' roofs, and the onset of the *brownout* effect. At this point, it is possible to see the downwash from the main rotor beginning to lift the dust particles from the landing site.

Figure 16 - Beginning of the *brownout* effect (left side view).

Figures 17 and 18 show the front and rear views of onset of the *brownout* effect.

Figure 17 - Front view of the onset of the *brownout* effect.

Figure 18 - Rear view of the onset of the *brownout* effect.

In the following two seconds, the *brownout* effect intensified, and the visibility deteriorated, causing the pilots to lose visual references with the ground (Figure 19).

Figure 19 - View of the *brownout* effect intensifying.

As soon as visual conditions were lost, the PIC initiated the go-around. However, the helicopter had a slight lateral displacement to the left, which caused the main rotor to collide with the upper part of the college building (Figure 20).

Figure 20 - Moment at which the main rotor blades collided with the facade of the building.

The pilots' reports to the Investigation Committee revealed that their individual perceptions in the moments before the collision with the building were similar.

According to the PIC, as soon as the dust began to cover the helicopter, the operational crew member uttered the "*Hold!*" command, after which he tried to keep the aircraft in hovering flight, vertically above the landing area, in order to wait for the dust to dissipate.

During the hover, the SIC was asked to activate the sand filter. At that moment, he heard the physician's command, "*To the right!*" and reacted accordingly right away, together with the attempt to go around. However, he sensed the collision on the flight controls and heard the noise of the blades hitting the building.

The PIC also said that he did not notice the helicopter moving to the left and that, despite the crosswind from the left, he believed that the structures of the buildings had interfered and "pushed" the aircraft to the left, causing the collision.

The SIC, in turn, reported that everything was normal until the dust covered the aircraft. He tried, for a few seconds, to view the ground through the lower left bubble, without success.

Immediately after activating the sand filter, the SIC looked to the left and saw that the wall of the building was close. Simultaneously, he heard the physician who was at the left door shout ("*to the right!*"). He tried to command the cyclic to the right and heard the noise of the impact.

According to the crew, they noticed no abnormal noises in the aircraft, no lights illuminating on the panel, no system malfunctions, no changes in the engine parameters, nor excessive yaw, pitching, and rolls before the impact.

The diameter of the main rotor was 10.69 m. The length of the aircraft - determined by the distance between the tip of the most forward main rotor blade and the tip of the most rearward tail rotor blade - was 12.94 m.

Considering that the landing site had a lateral dimension of 25.6 m after deducting the area of the bleachers, it is possible to state that, in an approach to the central point of the selected area, there were at least 14.9 m available to perform any necessary variations in the helicopter's axes (Figure 21).

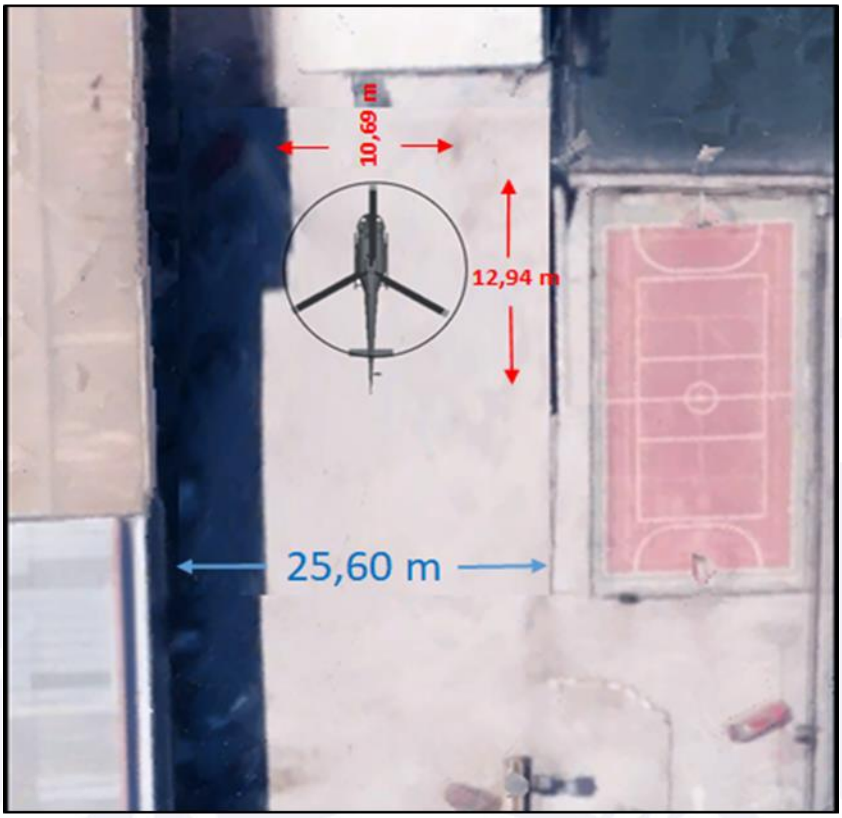

Figure 21 - Croquis of the accident site with the dimensions of the landing area and of the helicopter. Source: adapted from *Google Maps*.

1.19. Additional information.

The Command of Aeronautics' Manual (MCA) 3-6 *SIPAER Investigation Manual*, when addressing the topic "*Characteristics of Landing and Takeoff Areas*", warned of the fact that:

> Unprepared areas can present their own challenges to helicopter operations. Inadequate procedures during takeoffs and landings can generate restrictions on visibility, caused by the downwash effect of the rotor on dirt, sand or snow. In unprepared areas, consider the possibility that the landing gear may have hit terrain objects such as rocks, mounds of earth, termite mounds, or dense vegetation, initiating the sequence of events of the accident. Common errors made by pilots operating in unprepared areas are: not performing reconnaissance of the area, not checking the helicopter's performance data, and not avoiding prohibited areas of the height x speed diagram.

The 15th edition of the Aeronautical Accidents Prevention Newsletter for the Northeastern Region, dated April 2014, issued by the SERIPA II (Second Regional Service for Investigation and Prevention of Aeronautical Accidents), presented an article addressing the subject of "*Brownout Effect and the Risk to Rotary Wing Aviation*."

The publication described *brownout* as a phenomenon experienced by helicopter pilots during landing and takeoff operations in environments with sand or dust particles, which cause dust clouds to be suspended due to downwash from the main rotor, making it difficult to maintain flight using visual references in the aforementioned operations.

Downwash is characterized by the downward airflow produced by the main rotor of helicopters.

With a positive blade pitch-angle, the rotor disk induces an airflow through them, creating a column of downward air that is added to the relative rotational wind. This downward airflow is called induced flow (*downwash*). It is more pronounced in hovering flights under calm wind conditions (Figure 22).

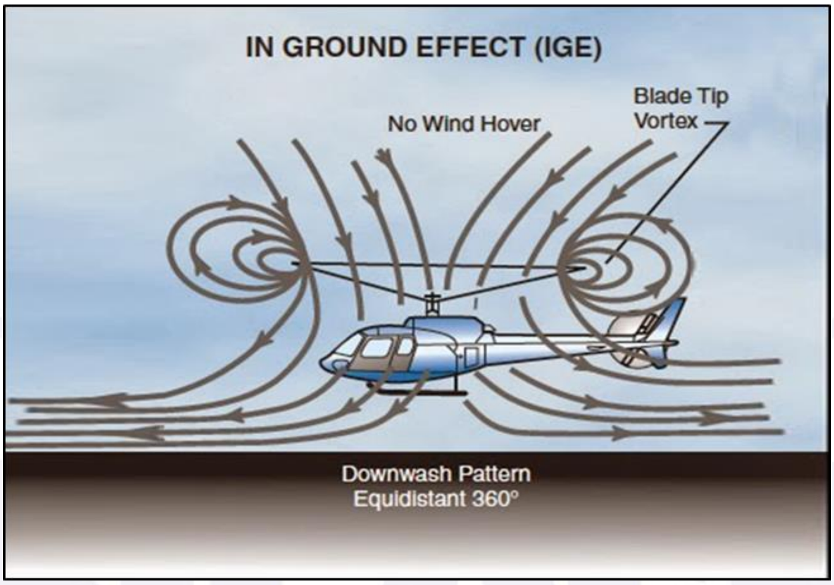

Figure 22 - Standard downwash in ground effect. Source: FAA *Safety Team*.

Thus, during the occurrence of a *brownout*, the *downwash* produced by the main rotor causes dust clouds to appear, making it difficult for the pilot to maintain external visual references. This scenario impairs the directional control of the aircraft, reducing the crew's situational awareness and, as a consequence, significantly increasing the risk of inadvertent collision with obstacles.

According to the 2012 study by the *Research and Technology Organization* (RTO) of the *North Atlantic Treaty Organization* (NATO), Technical Report - *Rotary-Wing Brownout Mitigation*: *Technologies and Training*[1], *brownout* can contribute to spatial disorientation due to its potential to reduce visibility and obscure the horizon. Thus, *brownout* is a situation in which the dust produced by the downwash reduces visual contact with the terrain and hides the horizon line, which may cause inadvertent drift, undetected banking, or even a false sense of movement.

In practice, when passing through a height of 75 ft., the downwash produced by the rotor may cause dust particles to rise in the air, leading to reduced visibility (Figure 23).

Figure 23 - Helicopter entering a *brownout* condition. Source: *Technical Report - Rotary-Wing Brownout Mitigation: Technologies and Training*.

According to the study, landing in degraded visual conditions is extremely dangerous. Thus, the pilot must properly assess the risk of the operation. For this reason, qualified crews and meticulous preparation and planning are essential prerequisites. The landing area, whenever possible, should be flown over, with attention to obstacles, wind direction, type of surface, go-around axes, etc.

1 NATO. RTO. **Rotary-Wing brownout mitigation: technologies and training**. Brussels: NATO, 2012

Landing upwind is always desirable, although the tactical situation may be a restrictive factor. If there is a crosswind, prioritize a landing being performed by the pilot who can remain outside the dust cloud for the longest time. The aircraft must always have sufficient power to initiate a go-around if the crew becomes disoriented or loses visual references. Finally, crews must be alert to possible illusions.

The Section 5.4 *Landing Techniques* of Chapter 5 - *Risk Management Strategies To Counter Brownout* of the *Rotary-Wing Brownout Mitigation*: *Technologies and Training* listed the following techniques used in landings under degraded visual conditions:

- *Direct Landing*: it is the most commonly used technique, as it reduces the time of exposure to the dust cloud. However, due to the movement during the flare, there is a greater risk of the rotor and tail cone colliding with the ground (Figure 24).

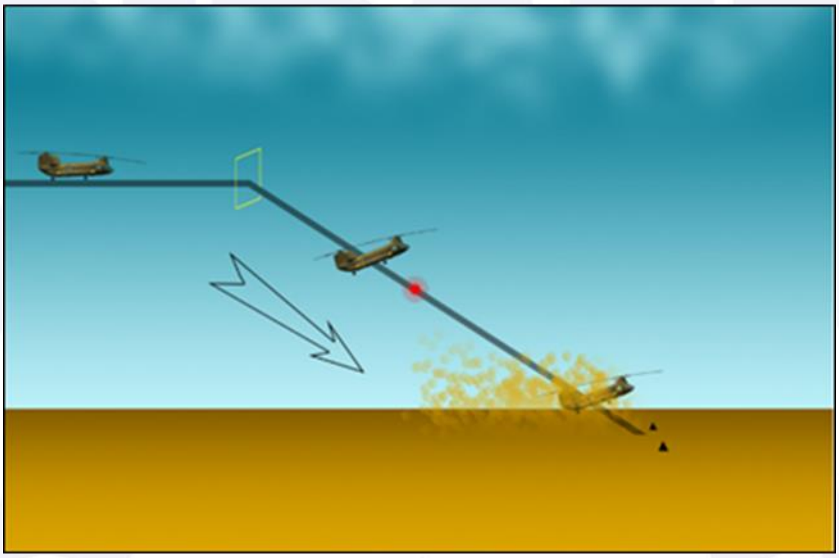

Figure 24 - Direct Landing. Source: *Technical Report – Rotary-Wing Brownout Mitigation: Technologies and Training*.

- *Short-Running Landing*: an approach similar to a direct landing, which ends with a short run on the ground. To do this, the crew must be certain of the type of terrain. Exposure to the dust cloud is reduced and the helicopter's stability is more effective. If it is a dirt surface, a faster landing should be used, thus avoiding recirculation after landing. The disadvantage of this technique is the risk of the aircraft's tail colliding with the ground and damaging the landing gear (skids or wheels) due to terrain conditions that could not be previously analyzed (Figure 25).

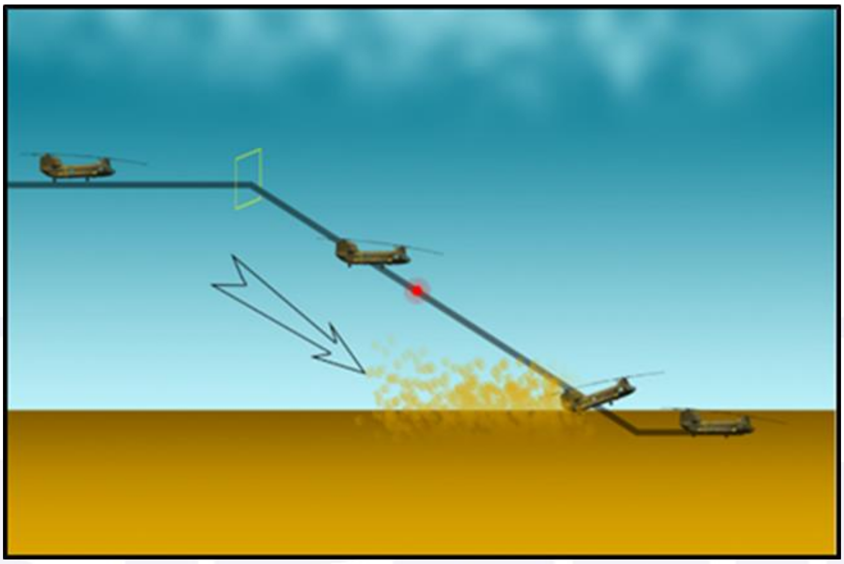

Figure 25 – Short-running landing. Source: *Technical Report – Rotary-Wing Brownout Mitigation: Technologies and Training*.

- *Low-hover landing*: although this technique allows for a better visualization of the landing site, the dust cloud is more significant if the ground is conducive to this condition. This type of landing may compromise the visual references used to maintain hovering, in addition to contributing to disorientation (Figure 26).

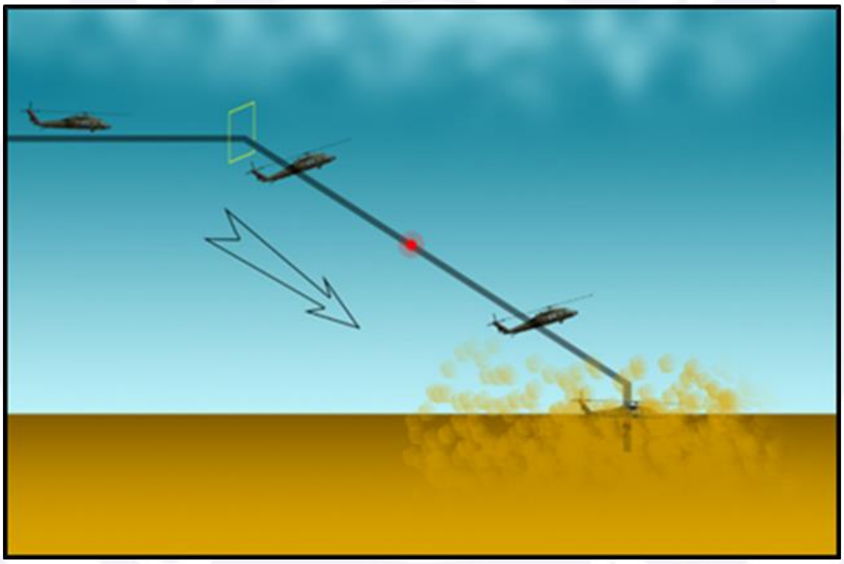

Figure 26 – Low-hover landing. Source: *Technical Report – Rotary-Wing Brownout Mitigation: Technologies and Training*.

- *High hover with vertical descent*: this technique requires a hover out of ground effect. It is recommended for automated landing or with additional guidance, unless the landing area has only a thin layer of dust or snow, and one is certain of the surface conditions (without obstructions and clean). This is the type of landing in which the helicopter will be subject to the greatest exposure to dust clouds, as well as disorientation, both when hovering and when descending vertically over the landing point. (Figure 28).

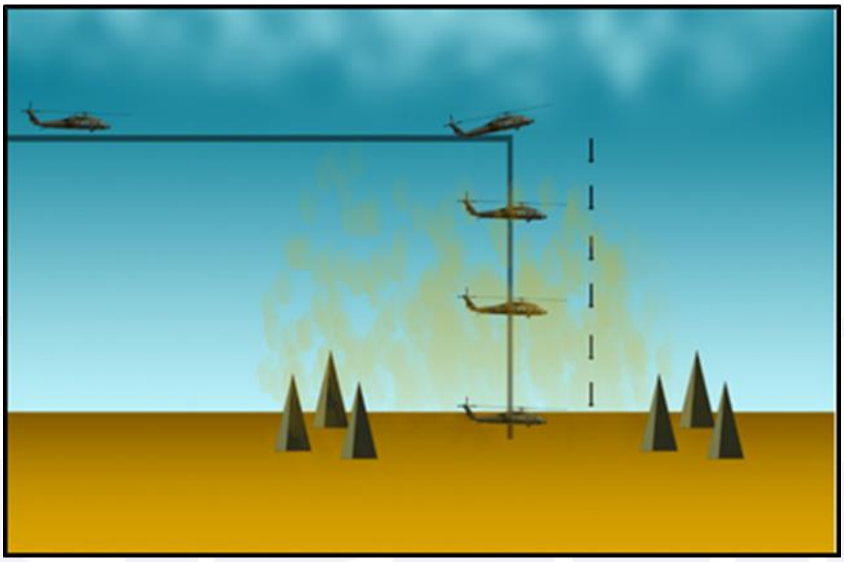

Figure 27 - High hover with vertical descent. Source: *Technical Report – Rotary-Wing Brownout Mitigation: Technologies and Training*.

The table in Figure 28 presents a comparison between the landing techniques presented in the study in question.

Approach	Advantages	Disadvantages	Requirements	Most Suited for
Zero Speed	↓ recirculation exposure. ↓ time in threat zone. No run on.	Nose up attitude. Risk of tail strike. High workload.	Accurate and controlled approach. Improved handling capability, needs adequate training.	LZ in high threat level environment. Precision LZ (e.g., FARP[1]). Tandem rotor or aircraft with good tail clearance.
Short Run-On	↓↓ recirculation exposure. ↑ stability in final approach. ↓ time in threat zone.	↑ risk from unseen obstructions, slope and poor surface. Risk of undercarriage damage. Risk of tail strike. High workload.	Surveyed LZ. Strong undercarriage.	Hostile LZ. LZ with few ground references. Tandem rotor or good tail clearance. Low CG.
Low Hover	Can visualize LZ. ↓ risk of tail strike.	Significant recirculation. Loss of HRM and drift.	Good HRM.	Indistinct surface. Poor tail clearance.
High Hover	Can visualize LZ. ↓ risk of tail strike.	Prolonged recirculation. Not suitable in threat environment. Loss of HRM and drift.	Benign tactical environment. Hover holds or orientation aids or good HRM. Light recirculation.	Confined areas. Prepared areas. Poor tail clearance.

Figure 28 - Comparison between landing techniques. Source: *Technical Report – Rotary-Wing Brownout Mitigation: Technologies and Training*.

The publication also explained that *brownout* contributes to the loss of visual references close to the ground, resulting in little tolerance for errors, untimely command corrections, and reduced situational awareness. The sudden loss of visual references induces major changes in the piloting process, which increases the possibility of disorientation. Likewise, the lack of technology and on-board instruments that can mitigate the risks of operating in a location susceptible to *brownout* further aggravates the problem. In turn, Nick Lappos, Sikorsky Aircraft Senior Technical Fellow in Advanced Technology, in an article published in the *Helitac* magazine, cited some recommendations that may be applied in order to prevent the *brownout* occurrence:

• Always take into account the possibility of *brownout* when planning the landing;

• Whenever possible, take off and land up wind;

• If possible, always make a direct takeoff and landing (without performing a hovering flight first);

• Power reserve is important. With little reserve, the chances of reversing a maneuver or doing a go-around are compromised; and

• If possible, check the location in advance to make sure that it is possible to perform a direct takeoff and a direct or a direct landing (area free of obstacles, ground with few undulations, etc.)

In his research on *brownout* in the aeromedical service operations of the *Santa Catarina* Military Fire Department (CBMSC), Coelho made a connection between *brownout* and public security flights, stating that:

> In the attempt to land in spots closer to the accident site, pilots in command of aircraft enjoy greater freedom to land in locations that are not approved and/or prepared for helicopter landings. As a result, there is a greater chance that they will have to land in places prone to *brownouts*, such as dirt football pitches, construction sites, among others [2] (COELHO, 2020, p.).

In order to reach the proposed objective, a questionnaire was prepared that sought to identify which types of measures the helicopter pilots operating in the CBMSC Air Operations Battalion were adopting in their flights.

The questionnaire consisted of 11 questions divided into two groups, one for pilots who had already experienced a *brownout* in their careers and the other for those who had not.

Nine pilots answered the questionnaire, and the results provided relevant information about the reality experienced by the crew members in their day-to-day rescue operations.

The first question addressed the pilots' experience, which ranged between 5 and 11 years of operation.

The second question showed that almost all pilots had already witnessed a brownout in their operational missions (Figure 29).

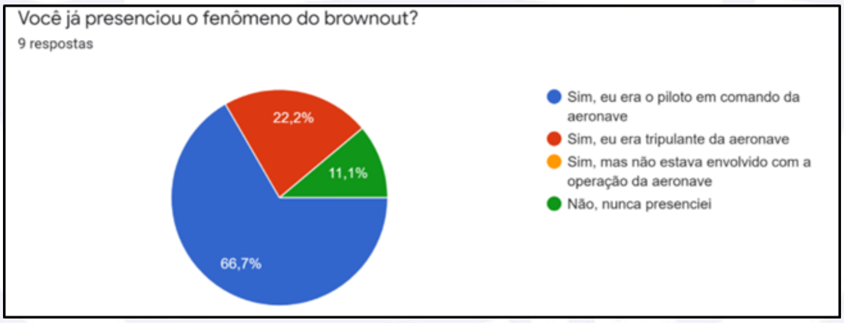

Figure 29 - Percentage of pilots who had already witnessed a *brownout*.
Source: Coelho, 2020.

The eight pilots who had already experienced the *brownout* phenomenon were directed to specific questions regarding how long ago the event had occurred, whether they were aware that the landing site was prone to *brownouts*, and what measures they took upon noticing the phenomenon.

Approximately 38% of the answers indicated that the pilots had experienced the *brownout* about a year ago. Another 25% had experienced it more than three years ago (Figure 30).

---

[2] COELHO, M. **O *brownout* nas operações de serviços aeromédicos do Corpo de Bombeiros Militar de Santa Catarina** -2020. Monografia, Ciências Aeronáuticas, Universidade do Sul de Santa Catarina. Palhoça, p. 35. 2020.

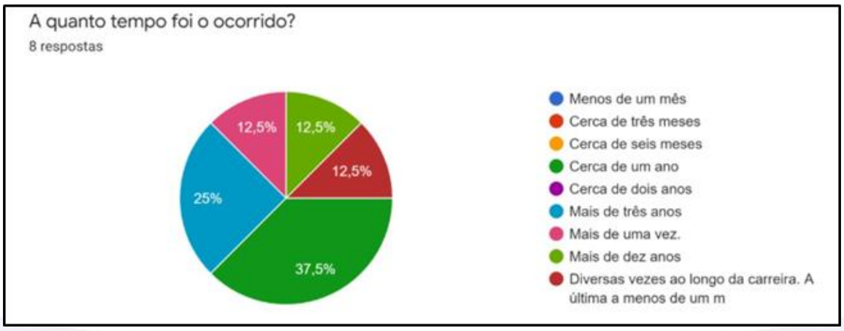

Figure 30 - Time elapsed since the event. Source: Coelho, 2020.

The majority of the pilots, approximately 62.5%, answered that they were not aware that the location was prone to *brownouts*, whereas the other 37.5% were aware of the possibility of the phenomenon in the location (Figure 31).

Figure 31 - Awareness that the landing would be carried out in a location prone to *brownouts*. Source: Coelho, 2020.

In relation to the measures taken, the majority of the pilots, 62.5%, decided to go around and head for another landing location not prone to *brownouts*. Other actions were also adopted by the remaining pilots. 25% continued to land, using recommended landing techniques, and the other 12.5% (equivalent to one pilot) noticed the dust rising and waited in a high hover until it dissipated, and then landed in the same place (Figure 32).

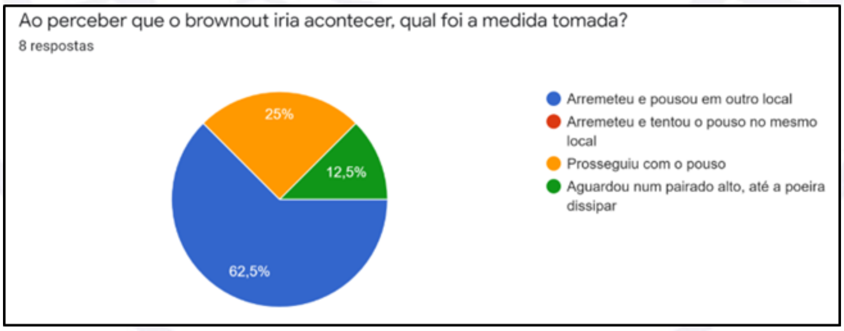

Figure 32 - Preventive measures adopted upon noticing the phenomenon. Source: Coelho, 2020.

Coelho (2020) asked the pilots to provide more details about the measures taken. The pilots' reports were organized according to the actions adopted, which are presented in Figures 33 and 34.

Procedimento	Relato	Ciência do *brownout*
Prosseguiu com o pouso	Durante o pouso em uma plantação, em dia muito seco, foi observado uma anormal suspensão de partículas de poeira. Próximo ao solo a visibilidade pelos vidros laterais e frontais da aeronave foi totalmente comprometida. Como pilot-flying, usei da escotilha próximo aos pedais para ter referência do solo, o qual estava visível devido ao downwash do rotor principal. Pouso feito com segurança. A decolagem do mesmo local foi mais fácil, pois, conforme a aeronave ganhava altura, a visibilidade melhorava.	Sim
Prosseguiu com o pouso	Aproximação direto ao ponto de toque a baixa velocidade sem perder totalmente o contato com o solo.	Sim

Figure 33 - Reports from pilots who continued with the landing. Source: Coelho, 2020.

Procedimento	Relato	Ciência do *brownout*
Arremeteu e pousou em outro local	No local da ocorrência havia poucos locais próximos para pouso, o mais próximo era um pátio de uma construção. Durante o procedimento de pouso, ao chegar a cerca de 100ft a poeira começou a subir e com cerca de 70ft era certeza que iríamos perder visão total do solo. Foi feito o procedimento de arremetida e foi realizado pouso em área gamada um pouco mais afastado. A equipe médica pegou carona em carro de populares até o local da ocorrência.	Não
Arremeteu e pousou em outro local	Nas operações do corpo de bombeiros, na maioria dos casos o pouso é em grupo de zulu, e sempre existe a possibilidade de que a poeira suba. Assim buscamos clarear a área, identificar potenciais riscos, definir a rampa de pouso e brifar o tripulante para que reporte em caso de poeira ou se voar algo (telhado, sacolas etc.), para que seja possível arremeter na rota previamente brifada. Realizamos o procedimento com muita calma para ter margem de tempo para reação.	Sim
Arremeteu e pousou em outro local	A última consegui arremeter. Em duas ocasiões o fenômeno se apresentou a poucos metros do solo, e optei por um pouso assertivo.	Não
Arremeteu e pousou em outro local	Na aproximação final, por conta do tempo seco e do terreno, já se preocupamos com o fenômeno, orientando a tripulação. Ao iniciar o levantamento da nuvem de poeira, procedeu-se a arremetida.	Não
Arremeteu e pousou em outro local	A minha experiência aconteceu no CBMDF em um combate a incêndio florestal. Estava na função de co-piloto e quando estávamos a mais de três horas em combate alertei o comandante sobre a situação de baixa quantidade de combustível. Já havia acionado o caminhão de abastecimento, e buscávamos o melhor local para pouso a fim de que o caminhão pudesse chegar até o helicóptero. Nesse interim, a luz indicativa de combustível acendeu, e estávamos com dificuldade de achar um local para pouso, quando avistamos um campo de futebol de terra e aproximamos para lá. Ao iniciar a aproximação para o pouso na vertical, uma nuvem de poeira começou a subir, e de imediato o tripulante solicitou a arremetida. Devido a inércia do helicóptero em iniciar a arremetida, ficamos cobertos por poeira entrando em condição IMC por segundos. Em seguida o pouso foi realizado em área segura, abastecida a aeronave e dado continuidade ao combate que durou aproximadamente três dias.	Sim

Figure 34 - Reports from pilots who performed a go-around and landed in another location. Source: Coelho, 2020.

It can be seen, therefore, that most pilots adopted the go-around and landing in another location as the preferred action in the event of a brownout.

Informal inquiries made by the Investigation Committee with various operational safety managers of Public Air Units indicated that the decision to either continue or discontinue the approach was at the discretion of the PIC and his experience, since there were no detailed procedures on how the crews should deal with the phenomenon.

On his part, Pinto (2011, p. 183)[3], when discussing the possibility of occurrence of human errors in the conduction of emergency missions by the Public Security Aviation in Brazil, highlighted that:

> A helicopter pilot of the public security aviation may, during an emergency mission, make at least 40 unanticipated and simultaneous decisions every four minutes of flight, involving flight maneuvers and management of the aircraft systems, from the beginning to the end of the mission (considering turns, simultaneous pedal applications, application of collective and cyclic commands, climbs and descents, radio communications, restricted landings and takeoffs, execution of checklists, constant changes in heading and speed, instrument panel scanning, among other tasks), in addition to ensuring flight safety and achieving success in the mission.

Still, according to Pinto (2011, p.178), emergency air missions can be divided into nine phases, with the fourth one being among the most critical (Figure 35):

Figure 35 - Complete cycle of a typical air operation of the Public Security Aviation. Source: Pinto, 2011.

In this phase, which corresponded to the visualization of the mission site and respective approach, Pinto (2011, p.180) reported possible errors, such as: (our emphasis)

> Hot entry at high speed into the approach circuit of the emergency mission, causing inattention to obstacles on the ground (high voltage wires, trees, poles, etc.) and accentuated flare for landing, favoring (subject to wind direction and strength) a possible pre-stall or flare power stall with accentuated nose-up with tailwind; <u>improper selection of the landing site (overly restricted area or touchdown area with too many irregularities)</u> creating a danger for disembarking or boarding; incorrect judgment on the approach in relation to the glide slope for landing or hovering with obstacles, associated with the direction and strength of the wind; incorrect use, or non-use, of the standard operational phraseology by the crew in coordinating approaches and landings in restricted areas;

[3] PINTO, Milton Kern. **A sobrevivência de helicópteros como um dos fatores preponderantes na aviação de segurança pública do Brasil**. Revista Conexão SIPAER, Brasília, v.2, n.3, p. 171-189, ago. 2011. Disponível em:http://conexaosipaer.cenipa.gov.br/index.php/sipaer/article/view/109/136>. Acesso em 21 Nov. 2020

distraction of the crew regarding coordination procedures in approaches, focusing greater attention (tunnel vision) on occurrences on the ground, such as: victims, other people, vehicles, etc., failure to see obstacles present on the approach slope to the restricted area (wires, birds, wind, towers, trees, etc.); inattention of the crew regarding the presence of people moving in the helicopter's landing/touchdown area; failure to plan in advance for a possible go-around away from the location being approached, wrong assessment of the availability of power reserves for possible obstacle crossing to the detriment of the required power; lack of coordination or incorrect cockpit phraseology in the actions and functions of each crew member when landing on rocks, elevated helipads or terraces of burning buildings; failure to apply effective situational awareness with decision-making and anticipated behavior when approaching and landing (restricted areas) in places where there are ground conditions that pose a risk to the landing of the helicopter, such as sand, dust, debris, wires, birds, towers, antennas, fire, smoke, large numbers of people and vehicles moving nearby.

For Barreto (2009)[4], of all the missions assigned for the Public Security Aviation, perhaps the one that involves the greatest risk of accidents is aeromedical rescue. According to the author, the impossibility of predicting certain variables during flight planning is one of the greatest difficulties for any pilot, and it has a decisive influence on the analysis of the management of the risk posed by the operation.

In this sense, Barreto (2009) highlighted the following variables that may be considered for the execution of the mission:

• unknown specific meteorological conditions at the landing site;

• unapproved landing site, and possibly unknown to the pilot;

• high probability of landing in a restricted area;

• limited time for mission planning, and its resulting pressure;

• little margin for errors and delays in the operation;

• possibility of operating in marginal flight conditions;

• presence of obstacles, such as: cranes, monuments, posts, wires, loose tiles, awnings, bushes, trees, stumps, rocks, trash, newspaper stands, commercial establishments (glass shops, restaurants, etc.), street markets, construction sites, etc.;

• presence of pedestrians, cars, trucks, buses, etc.;

• presence of animals, such as dogs and horses;

• the site may be on a declivity or acclivity, a fact that is difficult to observe when assessing the landing site; and

• landing and takeoff operations predominantly within the "dead man's curve" (height vs. speed).

The Section 90.173 - *Initial training: ground curriculum*, of Subpart M - "*Pilot Training*" of the RBAC-90 - "*Requirements for Special Public Aviation Operations*", stated that the general knowledge curriculum component should contain:

[...]

(15) the concept and/or procedures for prevention, as applicable:

(i) ground resonance;

(ii) collision with wires;

(iii) LTE;

(iv) dynamic and static roll;

---

[4] Barreto, A.M. O perigo do "*Brownout*" em uma missão de resgate aeromédico. **Resgate Aeromédico Aviação e Saúde**, 30 dez 2009. Disponível em: https://www.resgateaeromedico.com.br/brownout-em-resgate-aeromedico/. Acesso em 22 dez.2023.

(v) recovery from abnormal attitudes;

(vi) mast bumping and low G;

(vii) vortex ring;

(viii) runway excursion and incursion; and

(ix) deep stall;

(16) procedures for a stabilized approach; and

(17) other special conditions deemed relevant by the UAP.

[...]

The presence of *brownout* was observed in the following aeronautical incidents involving helicopters operated by the State Administration:

- PR-EKN

DATA	15OUT2013
AERONAVE	PR-EKN
MODELO	BK 117 C-2
CLASSIFICAÇÃO	INCIDENTE GRAVE
TIPO	OUTROS
LOCAL	ITAPIPOCA - CE
CATEGORIA	ADMINISTRAÇÃO DIRETA ESTADUAL

Figure 36 - Serious Incident with the PR-EKN.

In this event, the aircraft took off from SBFZ (*Pinto Martins* Aerodrome, located in the city of *Fortaleza*, State of *Ceará*) bound for *Itapipoca*, State of *Ceará*, at approximately 14:00 UTC, on a personnel transport flight, with 09 POB (a pilot and eight passengers).

During the landing on a football pitch, the main rotor's downwash raised dust and other debris, causing a momentary loss of visual references with the ground. The crew member, even without these references, continued to land. The helicopter remained in a pitched attitude, which caused the tail protector and the left vertical drift to touch the ground. The pilot and passengers were not injured.

- PT-SUS

DATA	28JUN2021
AERONAVE	PT-SUS
MODELO	AS 350 B3
CLASSIFICAÇÃO	ACIDENTE
TIPO	VOO CONTROLADO CONTRA O TERRENO - CFIT
LOCAL	JEQUITAÍ - MG
CATEGORIA	ADMINISTRAÇÃO DIRETA ESTADUAL

Figure 37 - Accident with the PT-SUS.

In this occurrence, the aircraft took off from SBMK *(Mario Ribeiro* Airport, *Montes Claros*, State of *Minas Gerais*), bound for an unregistered landing area located in the municipality of *Jequitaí*, State of *Minas Gerais*, at approximately 12:35 UTC to provide aeromedical care, with 04 POB (a pilot, a tactical air-operator, a physician, and a nurse).

During the landing at the destination, a cloud of dust formed (*brownout*) and the aircraft rolled sideways to the left. The aircraft sustained substantial damage. The pilot, the tactical air-operator, and the nurse were not harmed. The physician suffered serious injuries.

Figures 38, 39 and 40 show the sequence of the final approach for landing of the PT-SUS and shows the formation of the brownout.

Figure 40 – Rise of particles in the landing area caused by the downwash of the main rotor.

Figure 41 - Helicopter under the brownout effect.

Figure 42 - View of the PT-SUS after the accident.

1.20. Useful or effective investigation techniques.

NIL.

2. ANALYSIS.

It was a daytime visual flight with the purpose of providing first care to a victim of CPA (cardio-pulmonary arrest) and take them to a hospital.

During the final approach for landing at a college parking lot, the main rotor blades collided with the facade of a building. There was damage to a vehicle parked nearby, to the facade of the college building, and to a window of another building near the accident site.

The pilots were qualified and had experience in the type of flight. They also held valid CMAs.

The records of the airframe and engine logbooks were up to date. The CVA of the aircraft was valid. There was no evidence that any of the helicopter's systems contributed to the accident.

The aircraft was registered in the ADE Registration Category and operated under the rules of the RBAC-90 “Special Public Aviation Operations”.

The weather conditions were consistent with the type of flight.

The dimensions of the touchdown area (28.5 m x 74.3 m) were compatible with the operation of the AS-350 B2 helicopter.

Before landing, two orbits were performed verification of the wind direction, the type of surface, and possible presence of obstacles. After evaluating the factors that could interfere with a safe landing, a north heading was chosen, as it was considered the best choice for a contingent go-around.

Although the surface of the selected *ZPH* was made of concrete, it was covered by a considerable amount of dust and debris, due to the prolonged dry season in the Federal District and to the degradation of the surface.

Thus, during the approach for landing, when the helicopter reached approximately the height of the buildings surrounding the *ZPH*, sand particles from the landing area were suspended. The formation of this cloud of dust resulted from the downwash produced by the main rotor.

Thus, the occurrence of the *brownout*, in this critical phase of the flight, caused the loss of visual references close to the ground, resulting in little tolerance for errors, for untimely command corrections, and for reduced situational awareness. The sudden loss of visual references increased the possibility of disorientation.

At the same time, the helicopter's directional control was compromised, significantly increasing the risk of an inadvertent collision with obstacles near the *ZPH*.

Corroborating this statement, despite the attempted go-around, the helicopter, moving sideways to the left, impacted the lateral facade of the college. Incidentally, the PIC reported that he did not visualize the collision and that he just felt it on the flight controls and heard the noise of the blades hitting the building.

After evaluation of the scenario, one identified several relevant aspects that were present in the management of the operation which culminated in the accident in question.

Initially, it was found that the procedures adopted during the landing caused visibility restrictions due to the downwash effect of the rotor on the terrain. Similarly, although the *CBMDF* aircraft had already operated in that *ZPH*, the accumulation of dust at the site, caused by the long period of drought in the Federal District, was a determining factor for the occurrence of *brownout*.

Although the *MGSO* (SMM) of the *CBMDF* established a CFIT prevention program, as well as specific procedures for landing in urban and non-urban *ZPHs*, with regard to *brownouts*, the guidelines were succinct and limited to alerting the crew members to the possibility of the rise of solid particles during the landing in non-urban *ZPHs*.

As for landing in urban areas in places with sandy or muddy terrain, the study recommended that:

> Should a vehicle with water be available, prepare the landing area by wetting the touchdown point in order to prevent dust from affecting the landing of the aircraft, thus compromising the safety of the operation.

That said, it was noted that the manuals made available for the crew members to perform their duties were inadequate, especially with regard to the content relative to the *brownout* effect.

There was no standardization on which option would be the best one in the presence of *brownout*. The decision to either continue or discontinue the approach was left to the PIC's discretion, based on his/her experience, since there were no detailed procedures on how the crews should deal with the phenomenon.

In the publications presented to the Investigation Committee, nothing was found in terms of techniques used for landing in degraded visual conditions, such as those presented in the 2012 publication *Rotary-Wing Brownout Mitigation: Technologies and Training*, issued by the *Research and Technology Organisation* (RTO) of the North Atlantic Treaty Organisation (NATO).

In relation to the operation of the PR-MJX helicopter, according to a report made by the PIC, as soon as the dust began to surround the helicopter, the operational crew member gave the command of "*Hold!*" In response, the PIC tried to keep the aircraft in hovering flight, vertically above the landing area, in order to wait for the dust to dissipate.

In face of the imminence of the collision, the physician requested the helicopter to move to the right. According to the PIC, despite not having noticed the helicopter moving to the left, the request was immediately put into action, together with the attempt to go around, which, however, proved to be fruitless, since the collision was only perceived on the flight controls and in the noise of the blades hitting the building.

As for the technique utilized, the *Rotary-Wing Brownout Mitigation: Technologies and Training* only recommended a high hover with vertical descent (hovering out of ground effect) in the case of an automated landing or with additional guidance, unless the landing area had just a thin layer of dust or snow, and one was certain that the surface conditions were clean and unobstructed, which was not the case.

Furthermore, according to the NATO's publication, this is the type of landing in which the helicopter is subject to the greatest exposure to dust clouds, as well as to disorientation both during the hover and during the vertical descent for landing.

In view of this, it was found that performing the hover out of ground effect, in a location where the dust cloud was hard to dissipate due to the proximity of the buildings, contributed to the worsening of the brownout and, consequently, to the loss of the hover references and deviation to the left that culminated in the collision with the building.

In relation to the wind, landing upwind is always desirable, although the tactical situation may become a restrictive factor. If there is a crosswind, as was supposedly the case in this occurrence, it is recommended that the pilot capable of remaining outside the dust cloud for longer should be the one to perform the landing. In this episode, however, the effectiveness of the wind in dissipating the dust was compromised by the building against which the helicopter collided.

In his research on *brownouts* in the aeromedical service operations of the *Santa Catarina* Military Fire Department, Coelho (2020) linked *brownouts* to public security flights, stating the following:

> In their quest to land in spots closer to the site of occurrence, pilots in command of aircraft have greater freedom to land in locations that are not approved and/or prepared for helicopter landings. As a result, they are more likely to have to land in locations prone to *brownouts*, such as dirt football pitches, construction sites, among others.

After analyzing the results of the research, one was able to observe that there was no standardization on what would be the best option to be adopted in the presence of *brownouts*. In other words, according to the research, the decision to either continue or discontinue the approach was at the discretion of the PIC, based on his/her experience, since there were no detailed procedures on how the crews should deal with the phenomenon.

Informal consultations with several operational safety managers of Public Air Units corroborated such a perception.

For Barreto (2009), of all the missions allocated to the Public Security Aviation, perhaps the one involving the greatest risk of accident is the aeromedical rescue mission. According to him, the impossibility of predicting certain variables during flight planning is one of the greatest difficulties for any pilot, and it decisively influences the analysis of the operation risk management.

Furthermore, aeromedical operations, which aim to save human lives, tend to increase the motivation of their accomplishment, consequently increasing the possible related risks. This impulse can cause self-imposed pressure that eventually leads the team to operate with reduced safety margins.

That said, Nick Lappos, Sikorsky Aircraft Senior Technical Fellow in Advanced Technology, in an article published in the Helitac magazine, highlighted the following:

> • pilots should always take into account the possibility of brownout when planning the landing;
>
> • whenever possible, take off and land against the wind;
>
> • if possible, always perform a direct takeoff and landing (without establishing hovering beforehand);
>
> • power reserve is important. With little reserve, the chances of reversing a maneuver or making a go-around are compromised; and
>
> • if possible, check the location in advance to make sure that it is possible to perform a direct takeoff and a direct or run-up landing (area free of obstacles, ground with few undulations, etc.).

In relation to the processes aimed at refining the knowledge of the brownout subject, the section 90.173 - "*Initial training: ground curriculum*", of Subpart M - "*Training for Pilots*" of the RBAC-90, despite recommending that the UAP should include this phenomenon in the curricular component of general knowledge and other special conditions deemed relevant, *brownout* was not specifically mentioned in the regulation in question.

The information gathered in this investigation reinforces the need for Public Air Units to establish detailed and standardized procedures and that all crew members be prepared and trained to deal with the *brownout* phenomenon, aiming to ensure that the risks created by aeromedical rescue missions are valid in terms of cost-benefit and do not aggravate an already critical situation.

3. CONCLUSIONS.

3.1. Findings.

a) the pilots held valid CMAs (Aeronautical Medical Certificates);

b) the pilots held valid ratings for HMNT (Single-Engine Turbine Helicopter);

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

d) the aircraft had a valid CVA (Airworthiness-Verification Certificate);

e) the aircraft was within the weight and balance limits specified by the manufacturer;

f) the records of the airframe and engine logbooks were up to date;

g) the weather conditions were consistent with VFR flights;

h) no evidence was found of failures or malfunctions of the aircraft or its components that could have contributed to the occurrence;

i) the dimensions of the touchdown area were compatible with the operation of the AS-350 B2 aircraft;

j) the *ZPH* was covered with a large amount of dust and debris, due to the prolonged period of drought in the Federal District and to the degradation of the pavement;

k) during the approach for landing, the helicopter was subjected to the *brownout* effect;

l) the dust cloud produced by the rotor downwash reduced visual contact with the ground, and caused an inadvertent drift, making it difficult to maintain external visual references and compromising the directional control of the helicopter;

m) the main rotor blades collided with the facade of the college building;

n) the aircraft sustained substantial damage; and

o) the pilots and the other crew members suffered minor injuries.

3.2. Contributing factors.

- **Training – undetermined.**

The technique of hovering out of ground effect in order to dissipate the dust cloud showed that there may have been inefficiency in the processes of training crews to operate in areas subject to the *brownout* effect.

- **Disorientation – a contributor**.

The occurrence of *brownout* during such a critical phase of the flight made it difficult to maintain external visual references, and increased the possibility of disorientation. Regarding this subject, the PIC reported that he did not notice the helicopter moving to the left, something which compromised directional control. Despite the attempted go-around, the helicopter, moving sideways to the left, collided with the lateral facade of the college building.

- **Piloting judgment – a contributor.**

The selection of the technique utilized for landing the aircraft in an area subject to *brownout* was not appropriate. A high hover with vertical descent (hover out of ground effect) should only be performed in the case of an automated landing or with additional guidance, unless the landing area had just a thin layer of dust or snow, and one was certain that the surface conditions were clean and unobstructed, which was not the case.

- **Motivation – undetermined.**

Aeromedical operations, which are aimed at saving human lives, tend to increase one's motivation to perform the task and, consequently, the potential risks involved. Such drive may result in self-imposed pressure that eventually leads the team to operate with reduced safety margins.

- **Flight planning – a contributor.**

Although the selected *ZPH* had a concrete-paved surface, it was covered with lots of dust and debris due to the prolonged dry season in the Federal District and to the degradation of the pavement. Thus, the accumulation of dust at the site, caused by the long period of drought in the Federal District, was a determining factor for the occurrence of the *brownout*.

Thus, although the *CBMDF*'s helicopters had already operated at that *ZPH*, there was inadequacy in the work of preparation carried out for the flight in question, since there was no prior knowledge of all the operational conditions present at the landing site, something that had the potential to compromise the safety of the operation.

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

The PIC's decision to delay the go-around attempt, keeping the aircraft hovering vertically over the landing area in order to wait for the dust to dissipate, contributed to increasing the dust cloud and reducing external visibility, which led to the helicopter drifting laterally to the left, without the PIC having noticed the condition of imminent collision with the building.

- **Support systems – a contributor.**

In relation to the *brownout* phenomenon, the guidelines contained in the *CBMDF's* MGSO were succinct and limited to just alerting crew members to the possibility of solid particles rising during landing, only in non-urban types of ZPH.

There was no standardization on the best option to adopt in the presence of *brownout*. The decision to either continue or discontinue the approach was at the discretion of the PIC and his own experience, since there were no detailed procedures on how crews should deal with the phenomenon.

Similarly, the section 90.173 - "*Initial training: ground curriculum*", of Subpart M - "*Pilot Training*" of the RBAC-90 - "*Requirements for Special Public-Aviation Operations*" did not provide for a general knowledge curriculum component that included the concept and/or procedures for preventing the *brownout* phenomenon.

- **Other – Influence from the environment - a contributor.**

During the landing operation, a *brownout* occurred, a phenomenon experienced by helicopter pilots during landing and takeoff operations in environments with sand or dust particles. This causes clouds of dust to be suspended due to the downwash of the main rotor, making it difficult to maintain flight with visual references during such operations.

- **Other – *ZPH* Infrastructure - a contributor.**

The surface of the ZPH was covered by a large amount of dust and debris, due to the prolonged period of drought in the Federal District and to the degradation of the concrete pavement.

4. SAFETY RECOMMENDATIONS

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 consonance with the Law n°7565/1986, recommendations are made solely for the benefit of 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".

To Brazil's National Civil Aviation Agency (ANAC), it is recommended:

A-093/CENIPA/2020 - 01 **Issued on 08/14/2024**

To assess the relevance of including the *brownout* phenomenon in the curricular component of section 90.173 - "*Initial training: ground curriculum*", of Subpart M - "*Pilot Training*" of the RBAC-90 - "*Requirements for Special Public-Aviation Operations*".

A-093/CENIPA/2020 - 02 **Issued on 08/14/2024**

Disseminate, to Public Air Units which operate helicopters, the lessons learned in this investigation, so that, in the review of their manuals, operators can analyze the feasibility of including the techniques used for landing with degraded visual conditions, especially during the occurrence of the *brownout* phenomenon.

5. CORRECTIVE OR PREVENTATIVE ACTIONS ALREADY TAKEN.

The *CBMDF* issued a Standard Operating Procedure (SOP), detailing the procedures to be adopted by crews for the takeoff and landing of rotary wing aircraft.

The Section 3.5 - "*Reconnaissance and Landing in an Unregistered Area*" included the following standard steps:

• The crew visualizes the location of the occurrence;

• The crew evaluates the landing site (approach, go-around, and take-off ramps, terrain slope, free area dimensions, type of surface, proximity to the occurrence site, obstacles, and adjacent structures that can be damaged) in consonance with the recommendations listed in the Pilots' Manual;

• The crew performs the door opening procedure (phraseology for request and authorization by the 1P/2P). The PSE does not perform the procedure;

• The 1P/2P conducts a circular flyover for the crew to visualize the landing site in detail;

• The 1P makes a decision regarding the landing site and confirms it;

• The 1P/2P performs the approach and landing (piloting);

• <u>In cases of landing in places that may generate suspension particles, a high hover is performed to observe the behavior of the dust. Landing should be avoided near structures that do not allow the dispersion of dust. Height should be gained immediately if it is observed that non-visual flight conditions will result</u>; (emphasis added)

• The 1P/2P/TOp guide and move the aircraft for safe landing, according to cabin communication provided in the Air Operations Manual - Module III *Operational Crew*;

• The crew remains attentive to the landing, making safety-related reports using standard phraseology;

• The TOp makes the movements necessary for the visualization of obstacles near the aircraft or other unsafe conditions. If necessary, he/she keeps connected to the aircraft just by the safety anchor, without temporarily using his/her seat belt. Before landing, he/she has to be seated in his/her seat; and

• The crew defines the theater of operations in accordance with the SOP (*POP*) for isolation of the safety area.

The Chapter 4 of the SOP, in turn, highlighted the following possibilities for error during the execution of an air rescue mission:

• Poor assessment of the selected landing point, failing to consider intervening factors such as size, type of terrain, proximity to the occurrence, structures at the site, and obstacles existing in relation to the landing point; and

• The crew does not realize that dust suspension may cause inadvertent entry into non-visual flight conditions.

With regard to the landing phase, the SOP established that, before landing, the crew should check the type and conditions of the terrain in order to diagnose the possibility of landing and the appropriate procedures for landing.

In this sense, the following factors should be observed:

• Wind direction;

• Existence of an "approach ramp";

• Technical feasibility for landing and subsequent takeoff;

• The safety of the crew, of the aircraft, of the persons involved in the occurrence, and of the general public present in the vicinity of the occurrence site;

• Existence of logs, termites, FOD;

• Proximity to vulnerable areas (loose roofs, debris);

• Type of terrain (sandy, asphalt, grass);

• Flat or sloped terrain; and

• Terrain conditions.

The pilot will inform that the aircraft is in a landing procedure, and the crew shall notify that they are aware of the procedure, starting the report with the crew member on the left side, and the crew member on the right side will guide the aircraft during the final for landing as follows. For purposes of better didactics, the word “helicopter” is being used, but it may be omitted in the phraseology.

▪ PIL – Attention, crew, on final for landing!

▪ TOp2 – Left, roger.

▪ TOp1 – Right, roger. Helicopter, forward!

▪ TOp2 – Left-side and tail, clear.

▪ PIL - Forward.

▪ TOp1 – Hold!

▪ PIL - Holding.

▪ TOp1 – Helicopter, downward!

▪ TOp2 – Left-side and tail, clear.

▪ PIL - Downward.

▪ TOp1 - Downward.

▪ TOp2 – Left-side and tail, clear.

▪ PIL - Downward.

▪ TOp2 – Left-side and tail, clear.

▪ TOp1 – Right-side and tail, clear. Clear to land!

▪ PIL – Roger!

After landing, the crew will check if the skids are properly supported and will perform the procedures to secure the aircraft, as described in a specific chapter.

In the Final Report of the serious incident involving the PR-EKN aircraft, published by the CENIPA on 04 September 2018, the following Safety Recommendations were forwarded to the ANAC:

IG-187/CENIPA/2013 - 01

Work with civil aviation schools so that these centers of helicopter pilot training emphasize in their courses the factors that contribute to the occurrence of *brownout*, especially during landings and takeoffs at non-approved or unregistered locations, and the risks associated with this phenomenon.

IG-187/CENIPA/2013 - 02

Disseminate the lessons learned in this investigation so as to alert helicopter pilots and operators of the risks associated with the occurrence of the *brownout* phenomenon, especially during landings and takeoffs at non-approved or unregistered locations.

In response, the ANAC reported that the Recommendations were considered to have been met for the reasons expressed below:

With regard to the first Recommendation, the competent sector of the ANAC sent electronic messages to the schools and flying clubs registered in its database, warning them of the risks of *brownouts* occurring in certain situations, also attaching some excerpts and photographs of the Final Report discussed here, as well as providing the electronic address https://www.pilotopolicial.com.br/brownout-em-resgate-aeromedico/ which directs to a very educational article about the conditions that make *brownouts* possible and ways to prevent the occurrence of the phenomenon. The entities were urged to include the topic in their PPH, PCH, and INVH courses.

With regard to the second Recommendation, it was considered to have been met with the publication of the Final Report on the ANAC's website, more specifically in the option of “Promotion of Operational Safety”.

On 12 July 2020, the ANAC published the Ordinance nº 1529, approving the Supplementary Instruction nº 141-007, Revision A, which deals with the Training Programs and the Manual of Instructions and Procedures for Civil Aviation Training Centers, incorporating the theme of *brownout* into helicopter pilot training courses.

On August 14th, 2024.