COMANDO DA AERONÁUTICA

CENTRO DE INVESTIGAÇÃO E PREVENÇÃO DE ACIDENTES AERONÁUTICOS

FINAL REPORT
A - 173/CENIPA/2018

OCCURRENCE:	**ACCIDENT**
AIRCRAFT:	**PT-FPS**
MODEL:	**AW109SP**
DATE:	**24NOV2018**

This report replaces the RF A-173/CENIPA/2018, from November 3rd, 2022, previously published on the CENIPA website.

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 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. 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 24NOV2018 accident with the AW109SP aircraft model, registration PT-FPS. The accident was classified as “[LOC-I] Loss of Control in Flight”.

During a private flight, with two crewmembers and four passengers, departing from the Cristália Helipad (SJOQ), Itapira - SP, to an unregistered location, in Campos do Jordão - SP, the aircraft crashed into the ground, close to *Pico do Itapeva*.

The aircraft was destroyed.

The two crewmembers and four passengers died.

An Accredited Representative of the *Agenzia Nazionale per la Sicurezza del Volo* (ANSV) - Italy, (State where the aircraft was designed/manufactured), an Accredited Representative of the National Transportation Safety Board (NTSB) - USA, (State where the engine components were manufactured) and an Accredited Representative of the Transportation Safety Board (TSB) - Canada, (State where the engine was manufactured) were designated for participation in the investigation.

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GLOSSARY OF TECHNICAL TERMS AND ABBREVIATIONS

ACC	Area Control Center
ACC-BS	Area Control Center - Brasilia
ACC-CW	Area Control Center - Curitiba
ADI	Attitude Director Indication
AFCS	Automatic Flight Control System
ALTA	Flight Director Altitude Acquire
ANAC	Brazil's National Civil Aviation Agency
ANSV	Agenzia Nazionale per la Sicurezza del Volo - Italy
APP-SP	Approach Control – São Paulo
ATS	Air Traffic Services
CA	Airworthiness Certificate
CENIPA	Aeronautical Accident Investigation and Prevention Center
CIRCEA	Airspace Control Circular
CIV	Pilot's Flight Logbook
CMA	Aeronautical Medical Certificate
CRM	Crew Resource Management
CVR	Cockpit Voice Recorder
DAU	Data Acquisition Unit
DCTA	Department of Science and Airspace Technology
DCU	Data Collection Unit
EFIS	Electronic Flight Instrument System
ELT	Emergency Locator Transmitter
FAA	Federal Aviation Administration
FDR	Flight Data Recorder
FIR-BS	Flight Information Region - Brasilia
FIR-CW	Flight Information Region - Curitiba
FMS	Flight Management System
FPL	Filed Flight Plan
GPS	Global Positioning System
HMLT	Helicopter Multi-Engine Rating
HSI	Horizontal Situation Indicator
IAS	Indicated Airspeed
IDS	Integrated Display System
IDU	Integrated Display Unit
IFR	Instrument Flight Rules
IFRH	Instrument Flight Rating - Helicopter
IMC	Instrument Meteorological Conditions

INMET	National Institute of Meteorology
IS	Supplementary Instruction
MCA	Aeronautics Command Manual
METAR	Aviation Routine Weather Report
NOTAM	Notice to Airman
NR	Rotor Speed
NTSB	National Transportation Safety Board (USA)
NVM	Non-Volatile Memories
PCH	Commercial Pilot License – Helicopter
PIC	Pilot in Command
PLH	Airline Pilot License – Helicopter
PPH	Private Pilot License – Helicopter
RAB	Brazilian Aeronautical Registry
RBAC	Brazilian Civil Aviation Regulation
RBHA	Brazilian Aeronautical Certification Regulation
RDM	Master Differences Requirement
SBGW	ICAO Location Designator - Guaratinguetá Aerodrome, SP
SBSJ	ICAO Location Designator - Professor Urbano Ernesto Stumpf Aerodrome, São José dos Campos - SP
SBTA	ICAO Location Designator - Taubaté Air Base - SP
SDAM	ICAO Location Designator – Amarais Aerodrome, Campinas - SP
SJOQ	ICAO Location Designator – Cristália Helipad, Itapira - SP
SERIPA IV	Forth Regional Aeronautical Accident Investigation and Prevention Service
SIC	Second in Command
TAWS	Terrain Awareness Warning System
TPP	Registration Category of Private Service
TSB	Transportation Safety Board – Canada
UTC	Universal Time Coordinated
VFR	Visual Flight Rules
VMC	Visual Meteorological Conditions

1. FACTUAL INFORMATION.

Aircraft	**Model:** AW109SP **Registration:** PT-FPS **Manufacturer:** *Agusta*	**Operator:** *Cristália Prod. Quim. Farmacêuticos* Ltd.
Occurrence	**Date/time:** 24NOV2018 - 1250 UTC **Location:** *Pico do Itapeva* **Lat.** 22°45'20"S **Long.** 045°31'42"W **Municipality – State:** Campos do Jordão – SP	**Type(s):** "[LOC-I] Loss of Control in Flight" **Subtype(s):** NIL

1.1 History of the flight.

The aircraft took off from the Cristália Helipad (SJOQ), Itapira - SP, to an unregistered location in Campos do Jordão - SP, in order to transport personnel, with two pilots and four passengers on board.

The aircraft had the Emergency Locator Transmitter (ELT) activated and did not arrive at the destination on time.

After the search by the rescue team, the helicopter was found near the *Pico do Itapeva*, in Campos do Jordão - SP.

The aircraft was destroyed.

The two crewmembers and four passengers suffered fatal injuries.

1.2 Injuries to persons.

Injuries	Crew	Passengers	Others
Fatal	2	4	-
Serious	-	-	-
Minor	-	-	-
None	-	-	-

1.3 Damage to the aircraft.

The aircraft was destroyed.

1.4 Other damage.

None.

1.5 Personnel information.

1.5.1 Crew's flight experience.

Flight Hours	PIC	SIC
Total	1.169:00	1.400:00
Total in the last 30 days	05:54	01:25
Total in the last 24 hours	00:00	00:00
In this type of aircraft	14:13	53:46
In this type in the last 30 days	00:00	01:25
In this type in the last 24 hours	00:00	00:00

N.B.: The data relating to the hours flown were obtained by verifying the records entered in the Pilot's CIV, in the digital CIV and in the logbook of the crashed aircraft. The CIVs of the two crewmembers were outdated.

Thus, the flight hours recorded were those registered, as prevised in the regulations.

The functions on board the aircraft were informed by the operator. Due to the condition of the wreckage, it was not possible to determine the position of the crewmembers in the aircraft's cabin.

1.5.2 Personnel training.

The PIC took the PPH course at the *Escola de Aviação* Skyline, Campinas - SP, in 2001.

According to the ANAC's records, the SIC got his first PPH License in 04DEC2000.

1.5.3 Category of licenses and validity of certificates.

The PIC had a PLH License and had valid HMLT and IFRH Ratings.

Previously, he had the A19S rating, necessary for the operation of the A109E, A109S, and AW109SP models aircraft when these were considered "type" aircraft and a specific rating was required.

An endorsement for the AW109SP model was not found in the CIV of the PIC, after the change from the A19S rating to HMLT, according to the transition rule provided for in the Supplementary Instruction (IS) 61-006, between the publication dates of versions A (from 20APR2016) to version D (in force at the time of the accident).

The SIC had a PCH License and had valid HMLT and IFRH Ratings.

He received the endorsement for the AW109SP model on 10FEB2017 and took the proficiency exam on 31MAR2017.

1.5.4 Qualification and flight experience.

In order to analyze the pilots' qualifications, there was a need to review the regulations in force from 2014 to 2018, years that included the register of flight records by pilots when operating model AW109SP aircraft.

According to the survey, until 22APR2016, Amendment No. 05 of the RBAC 61 was in force, which defined that every helicopter was considered a "type" aircraft, requiring a specific qualification.

Supplementary Instruction No. 61-004 (IS 61-004), revision F, in force until 22APR2016; which defined the lists of qualifications that were added to the licenses; established the A19S type rating for pilots operating models A109E, A109S and AW109SP aircraft.

This IS determined a training of differences for the transition between variants or models of the same type of aircraft, according to item 5.3.4 (Figure 1).

Item 4.1.6, of the same IS, defined what would be a differences training, establishing the performance of a proficiency verification exam at the end of the training.

5.3.4 Nas Tabelas VII a XVI, a letra "D" da coluna "OBS" (3) indica que um Treinamento de Diferenças é requerido quando transitando entre variantes ou modelos de um mesmo tipo de aeronave, que estejam em células das colunas de "AERONAVE" (2) nas diversas Tabelas.

4.1.6 Um treinamento de diferenças é aquele que inclui tempo de instrução dedicada em sala de aula, com verificação de conhecimentos teóricos, podendo também incluir tempo de instrução em voo, com a respectiva verificação de proficiência, de acordo com o relatório de avaliação operacional do Grupo de Avaliação de Aeronaves da ANAC designado ou com o relatório de avaliação operacional da autoridade de aviação civil responsável pela certificação de tipo da aeronave.

Tabela XIV – Habilitação de Tipo (Helicóptero) – Operação *Multi Engine* (Motores Turboeixo)

FABRICANTE (1)	AERONAVE (2)		OBS (3)	DESIGNATIVO (4)
	MODELO	NOME		ANAC
Agusta	[illegible]	[illegible]		
	A 109 E	Power	D	A19S
	A 109 S	Grand		
	AW 109 SP	Grand New		

Figure 1 - Text extracted from IS 61-004, revision F. There were changes between 2014 and 2016 that did not affect the rules for the A109E, A109S and AW109SP.

The 2012 Operational Assessment Report for the Agusta 109 aircraft, in force in 2014 and 2015, advised pilots already holding a type rating on the need for differences training to transact from the A109E or A109S aircraft to the A109SP model aircraft (Figure 2).

TREINAMENTO		*TREINAMENTOS DE DIFERENÇAS*		
VARIANTES		A 109E ⇒ A 109S	A 109E ⇒ A 109SP	A 109S ⇒ A 109SP
VFR	Treinamento Teórico (incluindo o exame)	14h	24h	14h
	Treinador Sintético	–	3h	2h
	Simulador de Voo	–	–	–
	Helicóptero	2h	4h	2h
	Voo de Verificação de Proficiência	parcial	Parcial	parcial
IFR	Treinador Sintético	–	4h	4h
	Simulador de Voo	–	–	–
	Helicóptero	1h	4h	4h
	Voo de Verificação de Proficiência	Não Requerido	Não Requerido	Não Requerido

Figure 2 - Figure extracted from the Agusta 109 Aircraft Operational Assessment Report, issued by the ANAC in 2012.

As of 23APR2016, amendment 06 of RBAC 61 came into force, making the aircraft models A109E, A109S and AW109SP class aircraft, requiring HMLT certification.

At the time of the transition from "type" rating to "class" rating, there was concern about the impact of this change on the operating environment of helicopters, which have always been considered "type" aircraft.

This concern was included in the minutes of the ANAC Deliberative Meeting, of 18MAR2016, which approved amendment 06 of RBAC 61, where the following determination was recorded:

On that occasion, the Board of Directors determined that the SPO, over the next 04 years, monitor the changes implemented by this amendment about the new definition of aircraft type, especially observing the category of helicopters that have migrated to class Rating, annually presenting an operational safety report to the Board of Directors.

The publication of amendment 06 of RBAC 61 essentially meant two major novelties, both based on the FAA regulation No. 14 CFR Part 61:

- new parameters for aircraft requiring class or type ratings - general rule: those with PMD < 12,500 lbs, operating single pilot and not being turbojet/turbofan would be classified as “class” (including helicopters); while aircraft with PMD > 12,500 lbs, operating multi crew and being turbojet/turbofan would be classified as “type”; and

- the institution of endorsements (FAA endorsements), which would be assessments carried out by another pilot (a flight instructor, a commercial pilot, or an airline pilot).

Thus, on 23APR2016, IS 61-004, revision G, came into force with the new list of ratings, among them, the HMLT qualification. On the same date, IS 61-006, revision A, came into force, establishing the procedures for entering endorsements in pilot flight records, which was a novelty for the time.

In that IS, there was a specific endorsement for the variants or models A109E, A109S, and A109SP (Figures 3 and 4).

B6. EXEMPLOS:

- Determinado piloto já possuía, antes do dia 22/04/2016, a habilitação de tipo A109, com a qual voava aeronave do modelo A 109 A.
- Conforme o previsto no item B5.2.4 deste Apêndice, podemos afirmar que ele já se encontra endossado para todos os modelos da célula correspondente ao A 109 A, indicados abaixo:

CLASSE HELICÓPTEROS MULTIMOTORES

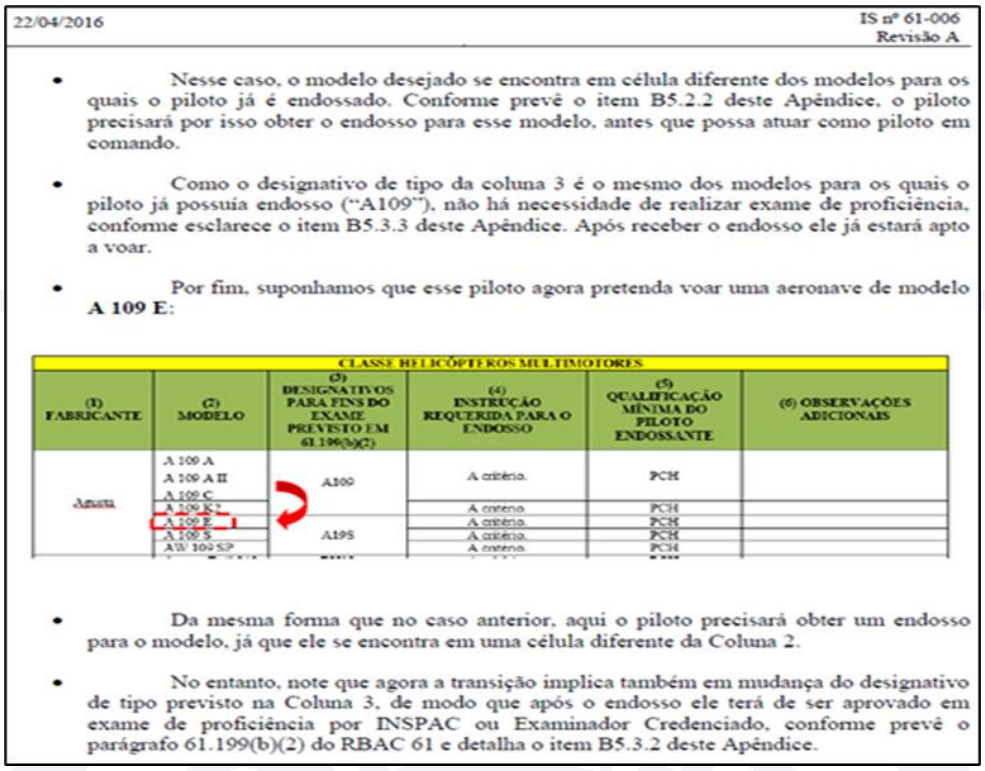
(1) FABRICANTE	(2) MODELO	(3) DESIGNATIVOS PARA FINS DO EXAME PREVISTO EM 61.199(b)(2)	(4) INSTRUÇÃO REQUERIDA PARA O ENDOSSO	(5) QUALIFICAÇÃO MÍNIMA DO PILOTO ENDOSSANTE	(6) OBSERVAÇÕES ADICIONAIS
Agusta	A 109 A A 109 A II A 109 C	A109	A critério.	PCH	
	A 109 K2		A critério.	PCH	
	A 109 E	A109S	A critério.	PCH	
	A 109 S		A critério.	PCH	
	AW 109 SP		A critério.	PCH	

- Caso este piloto pretenda voar um modelo A 109 A II ou A 109 C, ele não terá de realizar qualquer procedimento adicional, uma vez que este modelo se encontra na célula para a qual ele já se encontra endossado.
- Suponhamos agora que este mesmo piloto pretenda passar a voar uma aeronave do modelo A 109 K2:

CLASSE HELICÓPTEROS MULTIMOTORES

(1) FABRICANTE	(2) MODELO	(3) DESIGNATIVOS PARA FINS DO EXAME PREVISTO EM 61.199(b)(2)	(4) INSTRUÇÃO REQUERIDA PARA O ENDOSSO	(5) QUALIFICAÇÃO MÍNIMA DO PILOTO ENDOSSANTE	(6) OBSERVAÇÕES ADICIONAIS
Agusta	A 109 A A 109 A II A 109 C	A109	A critério.	PCH	
	A 109 K2		A critério.	PCH	
	A 109 E	A109S	A critério.	PCH	
	A 109 S		A critério.	PCH	
	AW 109 SP		A critério.	PCH	

Figure 3 - Example contained in IS 61-006 - revision A - appendix B.



22/04/2016 IS nº 61-006 Revisão A

- Nesse caso, o modelo desejado se encontra em célula diferente dos modelos para os quais o piloto já é endossado. Conforme prevê o item B5.2.2 deste Apêndice, o piloto precisará por isso obter o endosso para esse modelo, antes que possa atuar como piloto em comando.
- Como o designativo de tipo da coluna 3 é o mesmo dos modelos para os quais o piloto já possuía endosso ("A109"), não há necessidade de realizar exame de proficiência, conforme esclarece o item B5.3.3 deste Apêndice. Após receber o endosso ele já estará apto a voar.
- Por fim, suponhamos que esse piloto agora pretenda voar uma aeronave de modelo **A 109 E**:

CLASSE: HELICÓPTEROS MULTIMOTORES					
(1) FABRICANTE	(2) MODELO	(3) DESIGNATIVOS PARA FINS DO EXAME PREVISTO EM 61.199(b)(2)	(4) INSTRUÇÃO REQUERIDA PARA O ENDOSSO	(5) QUALIFICAÇÃO MÍNIMA DO PILOTO ENDOSSANTE	(6) OBSERVAÇÕES ADICIONAIS
Agusta	A 109 A A 109 A II A 109 C	A109	A critério.	PCH	
	A 109 E	A19S	A critério.	PCH	
	A 109 S A 109 SP		A critério.	PCH	

- Da mesma forma que no caso anterior, aqui o piloto precisará obter um endosso para o modelo, já que ele se encontra em uma célula diferente da Coluna 2.
- No entanto, note que agora a transição implica também em mudança do designativo de tipo previsto na Coluna 3, de modo que após o endosso ele terá de ser aprovado em exame de proficiência por INSPAC ou Examinador Credenciado, conforme prevê o parágrafo 61.199(b)(2) do RBAC 61 e detalha o item B5.3.2 deste Apêndice.

Figure 4 - Continuation of the example contained in IS 61-006 - revision A - appendix B.

Pilots who had the A19S type rating were subject to transition rules, with the preservation of their rights, as described below:

> 7. TRANSITION RULES
>
> 7.1 In cases where a new endorsement is required by Amendment 06 to RBAC 61 but was not required by the text of Amendment 05 of that regulation, this Supplementary Instruction will establish transition rules in order to preserve the acquired right of pilots who have already operated regularly under the previous rules.
>
> 7.2 The transition rules will be detailed on a case-by-case basis for each endorsement prevised in the body of this IS. Endorsements that do not have this detail do not have a transition rule and are considered required on the date of publication of this IS.

The Operational Assessment Report also underwent changes, the last one, revision 2, published on 23APR2016, with the following guidelines (Figure 5).

TREINAMENTO		SEM EXPERIÊNCIA PRÉVIA EM OPERAÇÃO DE HELICÓPTERO MULTIMOTOR A TURBINA				EXPERIÊNCIA DEMONSTRADA EM OPERAÇÃO DE HELICÓPTERO MULTIMOTOR A TURBINA			
MODELO REQUERIDO		A 109E		A 109S	A 109SP	A 109E		A 109S	A 109SP
		Helicóptero	Simulador			Helicóptero	Simulador		
VFR	Treinamento Teórico (incluindo o exame)	34h	34h	34h	48h	34h	34h	34h	48h
	Treinador Sintético	–	–	–	4h	–	–	–	2h
	Simulador de Voo	–	8h	–	–	–	4h	–	–
	Helicóptero	8h	2h	8h	8h	4h	2h	4h	5h
	Voo de Verificação de Proficiência	sim	sim	sim	sim	sim	sim	sim	Sim
IFR (caso aplicável)	Treinador Sintético	–	–	–	4h	–	–	–	4h
	Simulador de Voo	–	8h	–	–	–	6h	–	–
	Helicóptero	6h	2h	6h	6h	4h	–	4h	4h
	Voo de Verificação de Proficiência	sim	sim	sim	sim	sim	sim	sim	Sim

Figure 5 - Figure extracted from the Agusta Aircraft Operational Assessment Report 109 - revision 02, issued by the ANAC.

With the clarification of the regulations in force until the date of the accident, it was possible to verify the qualifications of the crew:

Pilot in Command (PIC)

The following aircraft brands that required the A109S type rating (later HMLT rating) were registered in the PIC's digital CIV: PP-AGT, PP-NNP, PR-YLO, and PP-CRM (all model A109E); PR-EDG and PT-LIA (both model A109S); PP-AGN and PT-FPS (both model AW109SP).

Regarding the AW109SP model aircraft, in the pilot's digital CIV records, four flights were found in 2014 on the PP-AGN aircraft, and the pilot himself requested their exclusions due to register error. A 1-hour instruction flight on the same aircraft was also found recorded in the digital CIV in 2015. All flights were recorded as review instruction on the AW109SP model aircraft, with a total of 4 hours and 39 minutes of flight time, 2 hours and 27 minutes of which were under Instrument Flight Rules (IFR - Instrument Flight Rules).

The two logbooks of the PT-FPS aircraft recorded a total of 9 hours and 34 minutes, all of them in the role of Second in Command. There was no record of hours flown on the PT-FPS aircraft under IFR conditions.

The total hours flown on the AW109SP model aircraft (PP-AGN and PT-FPS) were 14 hours and 13 minutes. In the digital CIV, there was an instruction and proficiency exam on the A109E and A109S model aircraft.

It was not found in the PIC records and in the ANAC records proficiency exam on AW109SP aircraft.

Thus, according to the transition rules, when migrating to the HMLT qualification, the PIC would be able to operate the A109E and A109S model aircraft. To qualify on the AW109SP model aircraft, the pilot would be subject to the endorsement rules established by IS 61-006.

No endorsement for the specific model class aircraft, model AW109SP, was found in all records held by the Investigation Team. Nor was theoretical training, synthetic training, or simulator on the aircraft found in any of the pilot's records.

It is noteworthy that, without endorsement and without a proficiency exam, the pilot would not be qualified to operate any AW109SP model aircraft in the role of PIC, except in instruction.

Thus, it was found that the PIC was not qualified and did not have experience in the aircraft to perform the flight.

Second in Command (SIC)

The SIC started his career and had experience in fixed-wing aircraft. In 2018, he carried out, in parallel, flights with fixed-wing and rotary-wing aircraft.

Received the endorsement for the AW109SP model aircraft on 10FEB2017 and performed the proficiency check flight on 31MAR2017 for revalidation of HMLT and IFRH qualifications.

The lack of detail, in the IS 61-006, of the instruction required for the endorsement, which left it to the endorser pilot's discretion, meant that the instructions received by the SIC did not generate supporting records (flight sheets, evidence, etc.) that could be inspected by the ANAC and analyzed by the Investigation Team, thus making it impossible to verify the quality of the instruction received by the endorsee.

On 11NOV2018, he carried out theoretical and practical training in a simulator, according to the certificate issued by Leonardo Helicopters, totaling 6 hours of simulated training, revalidating the IFRH rating.

In the two logbooks of the PT-FPS aircraft, a total of 53 hours and 46 minutes were recorded. Of this total, 2 hours and 10 minutes were flown in the PT-FPS aircraft under IFR conditions.

The SIC was qualified for the flight and had recent experience on the aircraft.

1.5.5 Validity of medical certificate.

The pilots had valid CMAs.

1.6 Aircraft information.

The AW109SP aircraft, serial number 22358, was manufactured by Agusta Westland in 2016 and was enrolled in the TPP Category.

The aircraft's CA was valid.

The airframe and engine logbook records were updated.

The last inspection of the aircraft, the “50 hours” type, was carried out on 25OCT2018 by the maintenance organization Helipark *Táxi Aéreo e Manutenção Aeronáutica* Ltd., in Carapicuíba - SP, with 5 hours and 22 minutes flown after the inspection.

The aircraft was equipped with a TAWS which used a database to alert the pilot of dangerous terrain or obstructions ahead of the aircraft.

1.7 Meteorological information.

The Investigation Team used data from the meteorological station of Campos do Jordão - SP, due to its geographical proximity to the place of occurrence. The station was managed by the INMET.

Figure 6 indicates the approximate distance between the INMET station and the impact site (7 km) and the difference in elevation between the two (198 m / 649 ft).

Figure 6 – Distance between the INMET and the occurrence site.

The following information were obtained about the INMET station (OMM:83714) in Campos do Jordão – SP:

Temp. Bulbo Seco	14.4°C
Temp. Bulbo Úmido	14.0°C
Umidade Relativa	96%

Figure 7 - Data used for the calculation. Source: BDMEP - INMET.

Through the Relative Humidity (RH) and Dry Bulb Temperature (T), it was possible to calculate the Dew Point Temperature (Td) and, consequently, to obtain the estimated height of the cloud base over the INMET station, obtaining the result of 246 ft for the base of the cloud layer.

In addition, meteorological RADAR images revealed precipitation conditions at 1240 and 1250 (UTC).

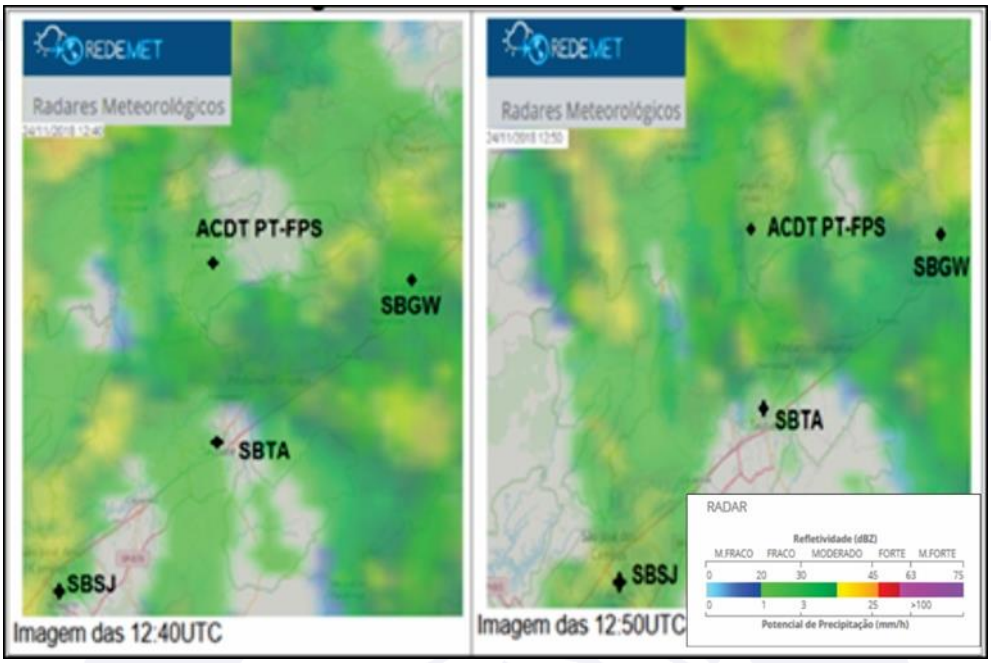


Figure 8 - Weather RADAR images.

According to the images, the accident region had weak to moderate reflectivity and a precipitation potential of approximately 1 to 3 mm/h at the time of the occurrence.

The METARs from the São José dos Campos (SBSJ), Taubaté (SBTA), and Guaratinguetá (SBGW) Aerodromes provided the following information:

METAR SBSJ 241200Z 06004KT 4000 -RA BR SCT009 SCT020 BKN080 21/20 Q1015=

METAR SBSJ 241300Z 06006KT 3500 -DZ BR SCT010 BKN020 BKN080 22/20 Q1015=

METAR SBTA 241200Z 05005KT 9999 -RA SCT035 OVC100 20/18 Q1014=

METAR SBTA 241300Z 04009KT 9999 -RA FEW027 SCT031 BKN100 21/18 Q1014=

METAR SBGW 241200Z 15003KT 3000 -RA BR SCT015 OVC080 21/19 Q1015=

METAR SBGW 241300Z 09005KT 4000 -RA BR FEW008 SCT015 OVC080 22/19 Q1015=

The METARs of SBSJ, SBTA and SBGW (the closest to the place of occurrence) described that there was precipitation, Light Rain (-RA) and Light Drizzle (-DZ) on these Aerodromes at the time of the accident. This information corroborates the weather RADAR images.

Regarding the flight rules for helicopters, the ICA 100-4, which dealt with the Special Air Traffic Rules and Procedures for Helicopters, established the following:

3.1 GENERAL CRITERIA

3.1.1 Within controlled airspace, a VFR helicopter flight will only take place when, simultaneously and continuously, the following conditions can be met:

a) remain in flight visibility conditions equal to or greater than 3000 m;

b) remain at least 1500 m horizontally and 500 feet vertically from clouds or any other meteorological formation of equivalent opacity; and

c) maintain reference with ground or water so that meteorological formations below flight level do not obstruct more than half of the pilot's vision area.

3.1.2 Outside controlled airspace, above 3000 feet altitude or 1000 feet above the ground, whichever is greater, a VFR helicopter flight will only be performed when, simultaneously and continuously, the following conditions can be fulfilled:

a) remain in flight visibility conditions equal to or greater than 3000m;

b) remain at least 1500 m horizontally and 500 feet vertically from clouds or any other meteorological formation of equivalent opacity; and

c) maintain reference with ground or water so that meteorological formations below flight level do not obstruct more than half of the pilot's vision area.

3.1.3 Outside controlled airspace, below an altitude of 3000 feet or an altitude of 1000 feet above the ground, whichever is greater, a VFR helicopter flight will only be carried out when, simultaneously and continuously, the following conditions can be fulfilled:

a) remain in flight visibility conditions equal to or greater than 1000 m, provided that the flight speed is sufficient to be seen and avoid traffic or any obstacle with enough time to prevent a collision: and

b) stay clear of clouds and maintain a reference to ground or water.

Thus, it was verified that, at the time of the occurrence, there were not the minimum ceiling and visibility conditions required for visual operations in the accident region.

1.8 Aids to navigation.

No records of flight plans for that aircraft were found.

The SJOQ Helipad was located in “Sector 2” of the ACC-BS, in the FIR-BS, whose airspace was classified as “Class G” (uncontrolled), from the ground to flight level 245 (FL245) and airspace A (controlled) above FL245, as shown in Figure 9.

The intended landing zone and the crash site (indicated as ZP and CS, respectively, in Figure 9) were within the lateral limits of the SBR-417 permanent conditioned airspace (vertical limits: ground at FL250), a restricted area for aircraft test flights.

Figure 9 – Take-off Location (SJOQ), Intended Landing Zone (ZP) and Crash Site (CS).

During the displacement between SJOQ and the intended landing zone/crash site, the aircraft took off from “Sector 1” of the ACC-BS (previously described), crossed “Sector 2” of this ACC, whose sector had the same descriptions as “Sector 1” and joined “Sector 8” of the ACC-CW, in the FIR-CW.

In this sector, however, according to the CIRCEA 100-71/2016, item 2.1.2, the provision of the ATS was performed by the APP-SP, by delegation of the ACC-CW, and the entire supposed route flown by the aircraft was within the lateral limits of overlapping restricted areas, from the ground to the unlimited, not having airspace classification, with the aircraft being subjected only to the flight information and the alert service.

If the aircraft, under VFR, flew over Sectors 1 and 2 of the FIR-BS, in which the airspace was classified as uncontrolled, there would be no obligation to submit a flight plan as item 2.3, of the MCA 100-11/2017.

As for the overflight of “Sector 8” of the ACC-CW, since the intended landing zone/crash site was within a conditioned airspace, classified as restricted, regardless of the flight rule (VFR or IFR), for entry into this area, the aircraft should have adapted to the determined restriction, except in case of prior coordination with the person responsible for the area. In addition, when entering it, he should have informed the APP-SP and kept listening to the body.

If the aircraft was under IFR, there would be an obligation to submit a flight plan, according to item 2.3, of the MCA 100-11/2017, and should have continuous bilateral contact, according to the ICA 100 -37/2018, ANNEX A.

1.9 Communications.

There were no records of communication between the aircraft and the control agencies. According to the NOTAM F2550/2018, in force on the day of the occurrence, the aircraft would only call the ACC-BS in case of emergency and should monitor the frequency of the corresponding sector of the ACC-BS.

1.10 Aerodrome information.

The occurrence took place out of the Aerodrome.

1.11 Flight recorders.

At the time of the accident, there was no homologation requirement or operational rule that required the installation of CVR or FDR in the AW109SP model aircraft.

Despite the absence of recorders, data were extracted from four IDUs that were part of the EFIS; the DAU; and two engine DCUs.

The location of the impact was confirmed using data extracted from the on-board GPS equipment.

The chip that contained the Integrated Display System (IDS), Status Log, was damaged and did not allow data extraction.

Due to the sudden loss of energy on the 28 VDC bus, the fault and exception records of the volatile memory buffer were not recorded in the NVM, a fact that made it impossible to record possible aircraft failures during the final flight.

1.12 Wreckage and impact information.

The aircraft crashed out of the Aerodrome, in a mountainous region near Campos do Jordão. The wreckage was concentrated and there was no fire in the components.

Figure 10 – General view of the aircraft at the crash site.

The aircraft's landing gears were found in a position compatible with that of “retracted” (Figure 11).

Figure 11 - Detail of the aircraft's landing gears.

The aircraft came to rest with a considerable portion of its front and upper fuselage section buried, evidencing a collision with a large angle and high speed (Figure 12).

Figure 12 – Detail of the upper frontal section burying, highlighting one of the main rotor blades.

According to data extracted from the DAU, the magnetic heading at the moment of impact was approximately 250°.

The inclination was at -70º and the aircraft penetrated the ground for about 5 meters, compacting the forward section.

1.13 Medical and pathological information.

1.13.1 Medical aspects.

To collect data on medical aspects, the following parameters were researched:

- Pilots' Health Inspections, Disclaimers and Medical Background Forms;

- necroscopic reports and toxicological tests; and

- routine of pilots in the 24 hours before the accident.

Health Inspections

With regard to the PIC, the Health Inspections carried out between 02JUL2016 and 02JUL2018 were verified, in addition to the Terms of Responsibility and Medical Background Form. The PIC was considered fit for air activity, with medical history of orthopedic surgery on the left knee and diabetes. However, no reference was made to the use of medications to control this last condition.

As for the SIC, the Health Inspections carried out between 19DEC2015 and 12DEC2017 were verified, in addition to the Terms of Responsibility and Medical Background Form. In the three Inspections performed, the SIC was considered fit for air activity, having, as a medical history, the use of corrective lenses and orthopedic surgery performed on the right knee on 15DEC2016. A history of smoking was reported, having stopped this habit more than ten years ago.

Necroscopic Reports and Toxicological Exams

The Necroscopic Report of the PIC, carried out on 25NOV2018, at 21:03 (local time), issued by the Legal Medical Institute - São Paulo, was analyzed. By analyzing the findings, both in the internal and external exams, it was concluded that all the injuries found resulted from multiple trauma due to the impact of the aircraft crash.

The SIC Necroscopic Report, carried out on 25NOV2018, at 21:07 (local time), issued by the Legal Medical Institute - São Paulo, was analyzed. From the analysis of the findings, both in the external and internal examination, it was concluded that all the injuries found were produced as a result of multiple trauma due to the impact of the aircraft crash.

Toxicological tests and alcohol dosage were also performed, with the result of both being negative for toxic agents. Toxicological tests and alcohol dosage did not detect any of these agents.

Pilots' routine in the 24 hours before the accident

It was found that none of the pilots had completed the flight stage in the twenty-four hours before the accident, and both had slept about eight hours, on average.

1.13.2 Ergonomic information.

Nil.

1.13.3 Psychological aspects.

The PIC had been temporarily hired to replace another company pilot who was on vacation during that period.

According to the information obtained, he had already worked professionally in a company from 2008 to 2017. In the last two years before the accident, he was flying without an employment relationship, when opportunities arose, but he expected to get a steady job.

The PIC was considered by professional colleagues as a skilled and experienced professional. He was described as a cheerful and outgoing person who enjoyed air activity.

According to family members, he had had a quiet routine the week before the accident, without flying. There were no reports of problems that could interfere with his professional performance.

According to reports from people close to the PIC, he had expressed satisfaction in carrying out that flight with the SIC, who was his longtime friend. According to reports, both had previously flown together on another company.

The SIC had been an employee of the company for four years. He was described by his co-workers as a focused professional. He was considered a confident and cheerful person, who had a good relationship with the people he worked with, being well-liked in the aeronautical environment.

According to the report of family members, there were no complaints from the SIC in relation to his employers as well as there were no reports of personal problems that could interfere with his performance.

1.14 Fire.

There was no fire.

1.15 Survival aspects.

There were no survivors.

1.16 Tests and research.

The aircraft's engines, PW207C, serial numbers BH0800, engine 1, and BH0802, engine 2, were taken to the Pratt Whitney (PW) shop in Sorocaba - SP, where they were analyzed by the PW Canada personnel and by an engineer from the DCTA.

Despite the damage caused by the aircraft hitting the ground, it was possible to dismantle several parts and see that the engines developed power at the moment of impact.

The DCUs of both engines were analyzed at the PW Canada's headquarters.

From the analysis of these components, according to the report generated by PW Canada, the following conclusion was drawn, as follows:

> The P&WC believes that the data captured by the DCU of the BH0800 engine only shows the recorded events that represent the maximum limit reached during each flight, which is the default recording. The data captured by the DCU of the BH0802 engine during the last flight shows evidence of both engines operating at full power, as seen by the recorded exceedances. The series of failures recorded in the BH0802 engine's DCU were impact related. The engines were producing power before impact and no indication of engine failure or problems were recorded by any DCU.

The visual information available on the ADIs and the HSI was reproduced in a simulation using the manufacturer's software.

The two monitors showed indications of height reduction in relation to the terrain, with yellow and red coloring in the map view on the HSI and in the corresponding sound and text messages.

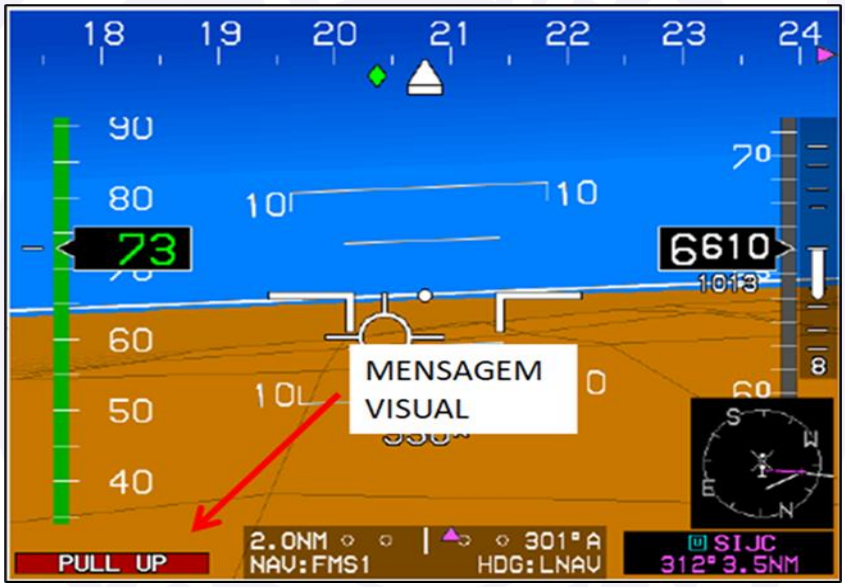


Figure 13 - Reproduction of the ADI indications during the final descent.

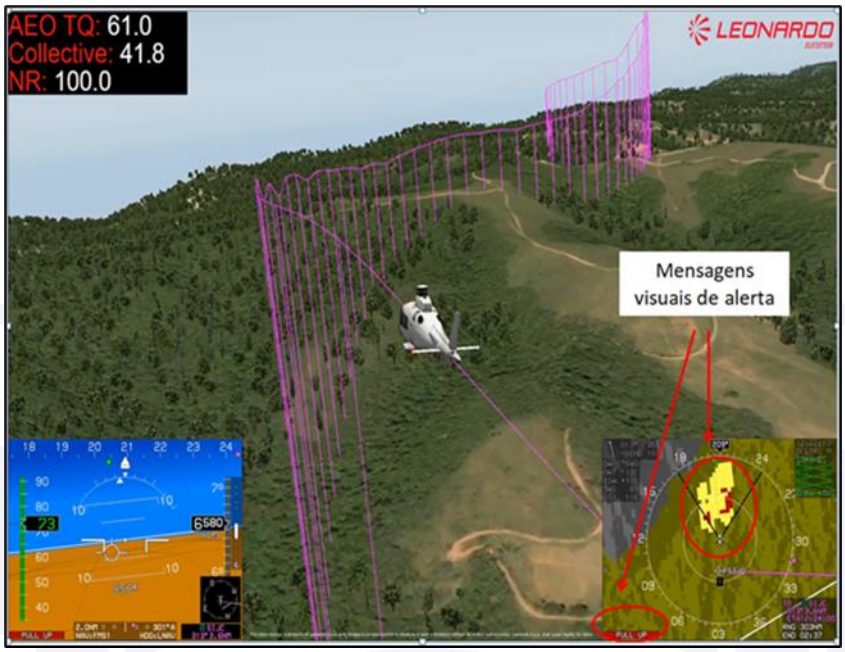


Figure 14 - Simulation of the ground approach with the visual terrain alerts.

Figure 15 - Reproduction of the HSI indications (in MAP format) during the final descent.

1.17 Organizational and management information.

Information about the management of the operation and the aircraft.

The aircraft with registration number PT-FPS belonged to a company that was not in the aviation industry, being registered for private flights (TPP category).

In the Full Certificate of the aircraft, issued by the RAB, it was stated that the company had been registered as the aircraft operator on 28JUL2016.

In this company, the air activities were subordinated to a sector called Administrative Support. According to the information obtained, flights were scheduled in advance, whenever possible, and there was no pressure at work.

As reported, the company gave pilots autonomy to decide on the appropriate conditions for flights.

It was reported that there was a respectful relationship between the sector manager and the pilots, who had periodic meetings to define operational and maintenance issues of the aircraft.

The management of the flight schedule occurred informally, being organized by the pilots themselves.

According to the data obtained, the flight requests were sent, in advance, to the executive secretary of the presidency who, in turn, forwarded them to the manager of the Administrative Support sector, via e-mail, with a copy to the pilots.

In some cases, the directors made the request directly to the pilots, who then formalized the process.

There was a policy that flights should always be performed with two pilots on board, this being a risk management measure adopted by the company.

Due to this fact, it was common for temporary hires of other pilots to occur, when there was a need to replace an unavailable crewmember due to vacation or other personal reasons.

According to the information obtained, the company's crewmembers indicated other pilots that could fly during this replacement period.

It was identified that the PIC had already performed other flights for the company, as a temporary crewmember.

About the crew composition, the RBHA 91, in force at the time of the occurrence, established the following requirements:

> 91.5 - CREW REQUIREMENTS
>
> (a) No person may operate a civil aircraft registered in Brazil unless:
>
> (1) the minimum crew of the aircraft is that established by its certificate of airworthiness;
>
> (2) When the certificate of airworthiness requires two pilots, one of them has been designated as the pilot-in-command of the aircraft; and
>
> (3) The operation is conducted by crewmembers suitably qualified for the aircraft and for their function on board and holding valid physical capacity certificates.

Thus, with the presence of two pilots on board, even in an aircraft certified for single pilot flights, it would be up to the operator the definition of the PIC and the SIC.

The pilot designated as PIC would have the final authority and responsibility for the operation and safety of the flight, as defined in the RBAC 01.

As reported during the investigation, the company was not aware that the hired pilot was not qualified to operate that aircraft model, because the sector responsible for hiring the temporary services did not verify the necessary qualifications of the commander.

According to what was reported in interviews, the company invested in training and maintaining the proficiency of its pilots. It was reported that the relationship between the pilots and their bosses was healthy, which allowed them to propose the necessary training courses, which were generally approved by the company.

Besides the technical training, the company's pilots participated, annually, in CRM training.

According to information gathered, both pilots involved in the accident had already participated in a CRM training. The last SIC CRM training was conducted in June 2018, months before the accident.

<u>Information about the familiarization process with the AW109SP and its differences.</u>

The A109 aircraft, versions A109E, A109S and AW109SP had differences, mainly in the avionics part, being the AW109SP panel entirely in glass cockpit model.

According to the Operational Evaluation issued by the ANAC, there was a RDM between A109E, A109S and AW109SP, as can be seen in Figure 16.

		Do Helicóptero	
		A 109E	A 109S
Para o Helicóptero	A 109S	D/D/D	-
	AW 109SP	D/D/D	D/D/D

Figure 16 - RDM between the 109E, S and SP aircraft.

According to item 5, of the Operational Evaluation:

> The reference for the triple ordered (Training/Checking/Currency - D/D/D) that appears in the cells of table 3 is the IAC 121-1009.
>
> The elements responsible for defining the "D" level of differences were the new 4 (four) axis autopilot model and the new cockpit layout adopted in the AW109SP variant.
>
> Note that the A109E and A109S were considered conventional cockpit helicopters, while the AW109SP was considered to have Digital Full Glass-Cockpit technology.
>
> Although all A109 family aircraft are operated with a multi-engine helicopter class rating, after differences training a partial proficiency check flight is required to assess competence for the trained maneuvers.

According to the excerpt above, it appears that for a pilot qualified in the A109E model aircraft to qualify in an AW109SP model aircraft, he needed to go through a process of familiarization with differences that included Training, Checking, and Currency.

According to the data obtained by the Investigation Team, it was not possible to prove that the PIC had carried out the necessary training on the differences between the aircraft.

Below, it's possible to check the differences between the versions of the aircraft panels.

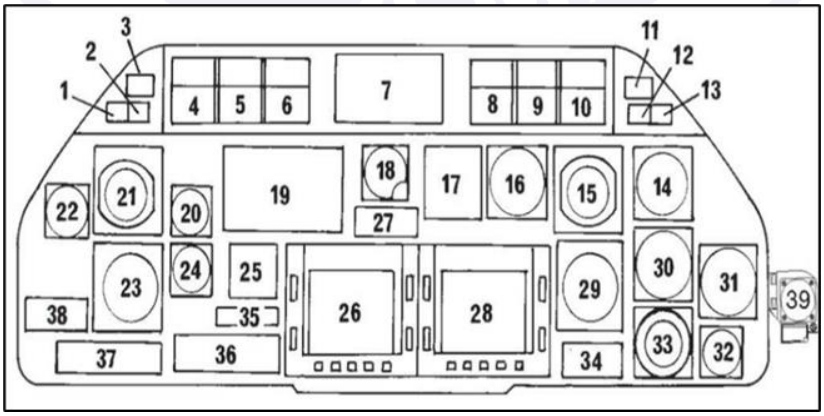


Figure 17 - Image of the A109E panel (taken from the Operational Evaluation Board Report - Final Report - Revision 1 - 29 05 2013-Manufacturer: AGUSTAWESTLAND - A109E, A109S & AW109SP).

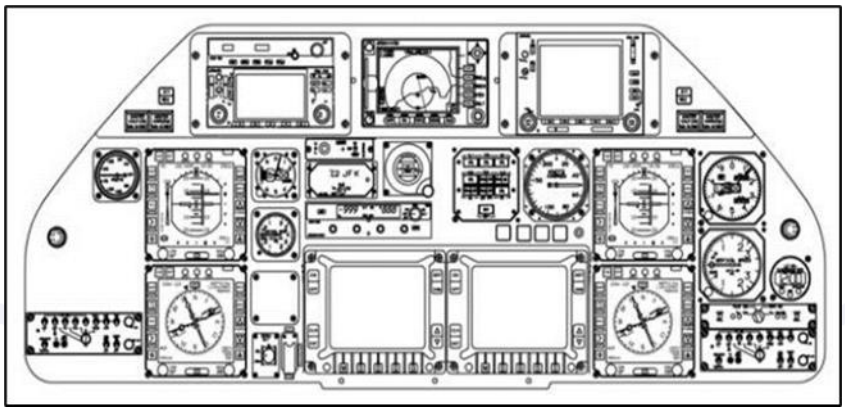


Figure 18 - Image of the A109S panel (taken from the Operational Evaluation Board Report - Final Report - Revision 1 - 29 05 2013-Manufacturer: AGUSTAWESTLAND - A109E, A109S & AW109SP).

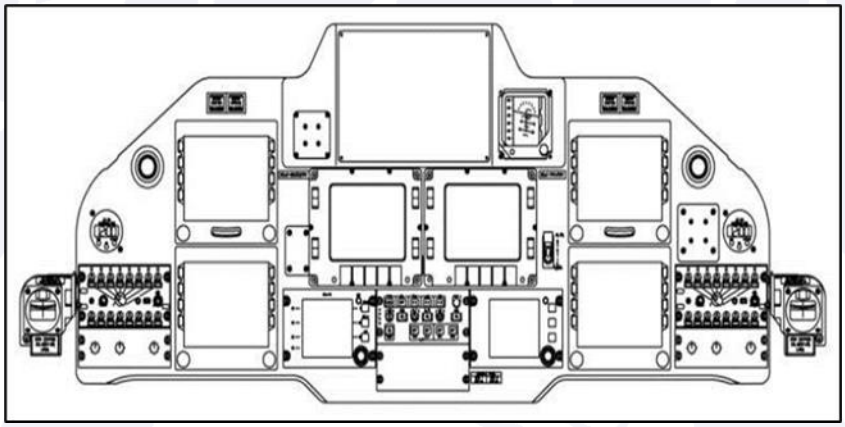


Figure 19 - Image of the AW109SP panel (taken from the Operational Evaluation Board Report - Final Report - Revision 1 - 29 05 2013-Manufacturer: AGUSTAWESTLAND - A109E, A109S & AW109SP).

On the date of the occurrence, the IS 61-006, revision D, was in force, which provided guidance on the endorsements issued, which should be entered in the crew's CIV, after the established criteria were met. It would also be up to the endorsee party to register in his digital CIV, according to item 8.2 of this IS transcribed below:

> 8.2 All endorsements prevised in this section must be entered in the CIV of the endorsee pilot by the endorser pilot, as well as recorded in their own digital CIV by the endorsee pilot.

As it was up to the endorsee to register, the ANAC was unable to verify, analyze and control the endorsements issued, as the information contained in the digital CIV was not reliable, requiring face-to-face verification and possession of the individual paper flight record.

Information about the traceability of the crew training process.

The Investigation Team did not find detailed records of flight instructions, flight records and crew evaluation evidence that could be analyzed.

Knowing that an individual's degree of competence depends on the sum of their knowledge, skills and attitudes, it was not possible to verify the quality of the knowledge received by the SIC in his instructions, in order to analyze whether the crew's training objectives were really efficient for the AW109SP model aircraft.

The lack of documentation may have been a result of the current regulation, IS 61-006, revision D, not detailing how theoretical and practical instructions should be given,

and what types of documentation should have been produced, leaving it up to the instructors.

B5.4. Coluna 4

B5.4.1. A Coluna 4 indica qual a instrução requerida previamente à concessão do endosso. Se esta coluna indicar instrução "A critério", o piloto endossante deverá ministrar a instrução de solo e de voo que se mostre suficiente para que o piloto endossado seja capaz de demonstrar total conhecimento e proficiência nos seguintes aspectos:

a) Estrutura, sistemas e limitações da aeronave;

b) Procedimentos anteriores ao voo, incluindo peso e balanceamento e verificação das condições gerais de aeronavegabilidade;

c) Procedimentos normais em solo e em voo;

d) Procedimentos anormais e de emergência em solo e em voo; e

e) Procedimentos em caso de falhas de equipamentos e de motor.

Figure 20 - Excerpt taken from the IS 61-006 revision D.

Although there is an Operational Assessment for the AW109SP model aircraft available on the ANAC website, it was not mandatory, being used only as a reference.

1.18 Operational information.

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

It was not possible to determine which of the two crewmembers was acting on the controls of the aircraft at the time of the accident. According to information obtained, it was the company's practice that, in a flight with two pilots, the pilot in the PIC role acted as Pilot Flying. This information was corroborated by the records of previous flights in the logbook of the PT-FPS aircraft, which indicated that the crewmembers registered in the "Commander" field were those who performed the piloting, being assisted by the crew registered in the "Copilot" field.

No flight plan record (FPL) was found for the route taken by the aircraft.

As there was no FPL and the locations did not operate IFR, the flight had to be conducted in VFR.

In visual conditions, the entrance to Campos do Jordão - SP, should be made with a visual reference of the city gate, passing through its interior and with a left turn to land in an unregistered place located in a private residence (Figure 21).

Figure 21 - Reproduction of a VFR flight trajectory in Campos do Jordão, carried out by the company.

During the field investigation, a compendium of charts with uncertified procedures was found in the wreckage of the aircraft (Figure 22).

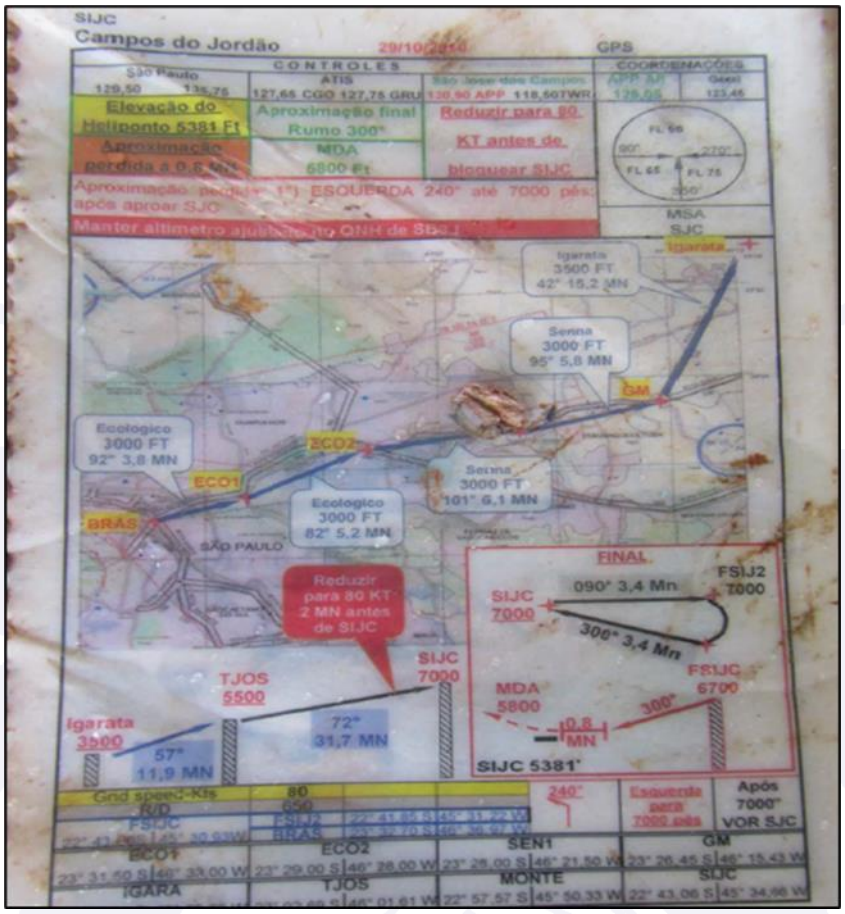


Figure 22 - Non-certified Procedure Chart.

An instrument approach procedure consists of a series of predetermined manoeuvres, with specific protection against obstacles, to a position in which the criteria of holding circuit or clear margin of obstacles en-route apply.

It should be noted that this type of procedure must be prepared by specialized technicians and in accordance with international safety standards.

According to the aircraft operator, the charts with the procedures did not belong to the company.

Upon retrieving the IDU data, it was found that there was a flight plan, recorded in the aircraft's FMS, defined as “SDAM-SIJC”.

The flight plan entered coincided with the points of a procedure called “Campos do Jordão”, which was found in the compendium of uncertified charts. SDAM was the designation of the Amarais Aerodrome, and SIJC referred, in 2010, to the Campos do Jordão Hotel Helipad and which, on the date of the occurrence, had the designation of SICH.

According to the data collected from the aforementioned equipment, the flight profile departed from SDAM, proceeded to the Cristália Helipad (SJOQ), flew over the Campos do Jordão Hotel Helipad (SIJC), performed a departure leg towards the FSIJ2 point, performed an approach turn to the FSIJC and, soon after, approach to the SIJC Helipad.

Also, from the data taken from the IDU, it was possible to retrieve information about the last flight performed. It was found that the PT-FPS flight trajectory corresponded exactly to this procedure, up to the middle of the approach turn, towards the FSIJC point, when the aircraft began to deviate significantly.

After passing through FSIJ2, the aircraft maintained 6,700 ft and 80 KIAS as it slowly exited a 25° bank right turn into an 8s 11° left turn at 12:21:06 (UTC).

According to the operation of the aircraft system, when the flight director was coupled to the FMS to obtain lateral navigation, the maximum angle of inclination that could be commanded by the AFCS of the AW109SP was 25°.

Therefore, based on the banks presented, it is likely that since the take-off from SJOQ to FSIJ2, the flight director was coupled to the aircraft's autopilot system. This scenario is reinforced by the overall evolution of speed, altitude and take-off data from SJOQ to FSIJ2, which showed little or no variation (Figure 23).

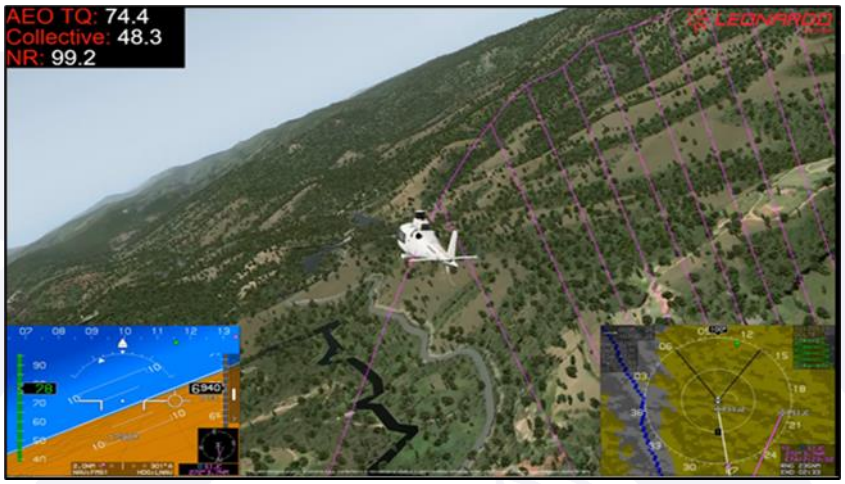


Figure 23 - Simulation of the turn to the right after passing the FSIJ2 point.

From this point forward, the flight parameters show a controlled trajectory towards the South (205°/210° magnetic heading), although with a profile compatible with a manual flight, due to the magnetic heading variation and the various small adjustments in attitude.

An automatic command from the FMS could be disregarded, as its maximum roll rate was 3°/s, while on the turn in question, the average variation recorded was above 4.5°/s. Thus, manual command of the right turn would be the only plausible explanation.

According to the recovered data, there is a possibility that there was an intervention, apparently manual by the crewmembers, to cancel the lateral orientation of the AFCS, during the base turn to the right for the intercept of the final approach, after passing the point FSIJ2.

In this way, the AFCS was directing the helicopter to intercept the next leg of the flight plan (FSIJC-SIJC) without blocking the FSIJC. However, the aircraft proceeded South with an average heading of 205° to 210° and a rate of descent of 600-700 ft/min, until, at a certain point, it began a steep climb, along with a constant change of direction heading to the right and approximately 40º of pitch angle.

As the active flight plan in the FMS contained a “discontinuity” the two points FSIJ2 and FSIJC were not connected by a continuous arc.

This may have occurred due to an insertion, intentional or not, of the discontinuity, since that procedure was not certified.

In this case, the AFCS, after passing the FSIJ2 point, would direct the aircraft to the closest intercept point of the FSIJC - SIJC leg without overflying the FSIJC, as shown in Figure 24.

Figure 24 - Simulated HSI with flight plan overlay in MAP format.

It should be noted that a dedicated check for continuity of the FMS approach was present in the AW109SP RFM for EFIS version 7.0F software, which was installed on the PT-FPS (Figure 25).

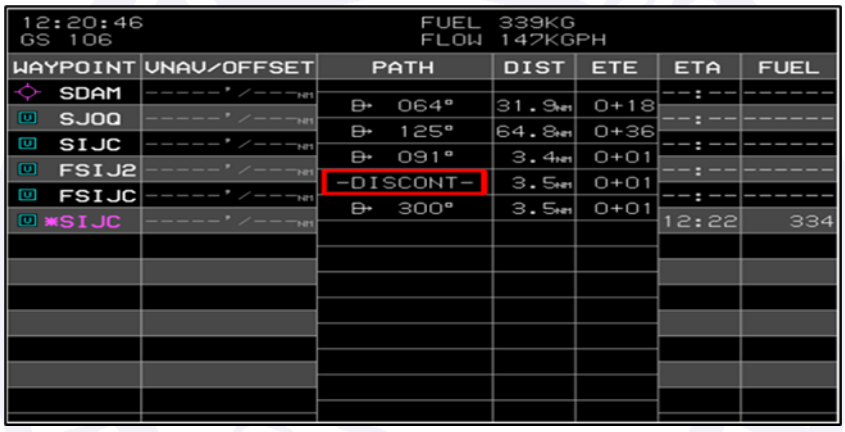


Figure 25 - NAV LOG page. The indication - DISCONT (red box added for clarity) appears in the two views between FSIJ2 and FSIJC.

CAUTION

Check FMS IFR procedures for continuity on MAP page or NAV LOG page after activating the procedure.
In case of discontinuites the FMS could not correctly follow the published procedure.
The pilot shall fly attentive and follow the published procedure.

CAUTION

To exit an FMS holding procedure press "CONT" softkey only when inbound holding waypoint.

Figure 26 - Extract of limitations of the AW109SP RFM - FMS in Section 1.

Figure 27 - Simulation of the deviation to the left, probably with manual heading variation.

Shortly after flying over the FSIJC, from 12:22:02 (UTC) onwards, the aircraft maintained a constant rate of descent of 600-700 ft/min.

After reaching the FSIJC point, the aircraft should have proceeded to heading 300°, towards SIJC, descending from 6,700 ft, according to the procedure.

However, the aircraft continued south with an average heading of 205° to 210° and a descent rate of 600-700 ft/min.

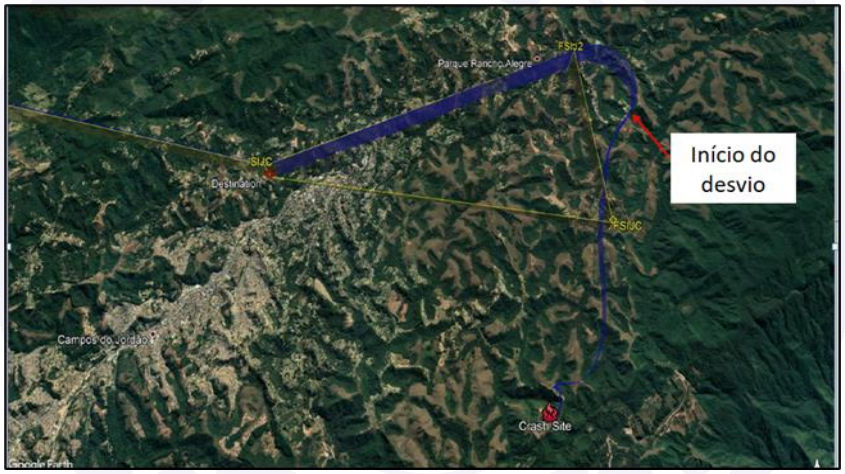


Figure 28 - Simulation of the route with the beginning of the detour.

Figure 29 - Reconstruction of the ADI view.

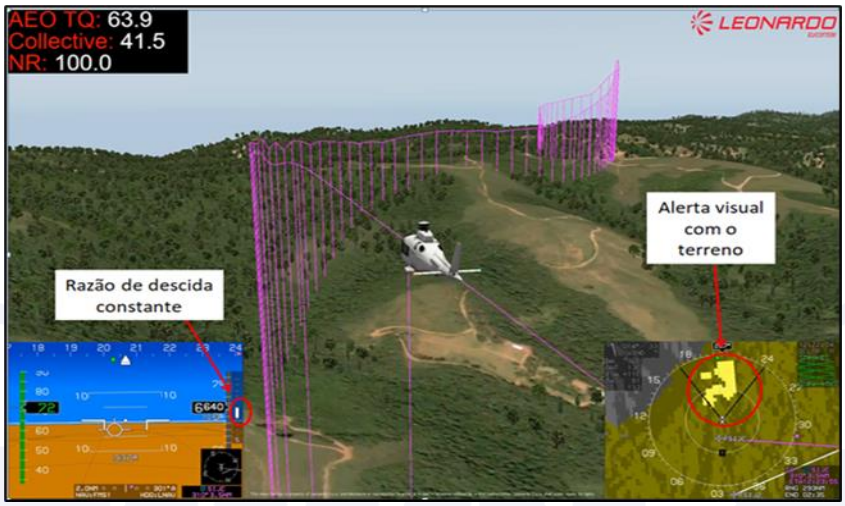


Figure 30 - Simulation of descent after FSIJC.

From that point, the aircraft started a steep climb, simultaneously with a constant change of course towards the right and, approximately, 40º of pitch angle.

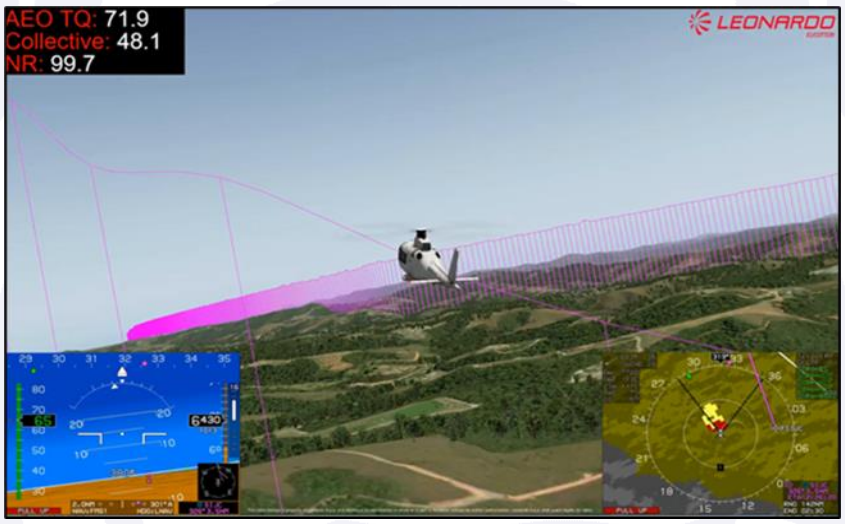


Figure 31 - Simulation of the climb and reduction of speed.

This sudden change in attitude provided a rapid reduction in speed that went from 80 to 0 KIAS when reaching the maximum recorded altitude of 6,980 ft, at 12:22:52 (UTC), followed by extreme variations of the aircraft attitude in its three axes.

Figure 32 - Simulation of the maximum altitude reached.

When the Torque (TQ) reached 220% and the collective was increased, the Rotor Speed (NR) started to drop below 100% at 12:22:58 (UTC).

This was consistent with the activation of the Engine Torque Limiter, a function that affects the PW207C engine which equipped the aircraft.

This function was activated through a button on the collective stick, as provided for in item 6 of the pre-takeoff checks, contained in the regular procedures of the aircraft manual (AW109SP RFM Document No. 109G0040A018) (Figures 33 and 34).

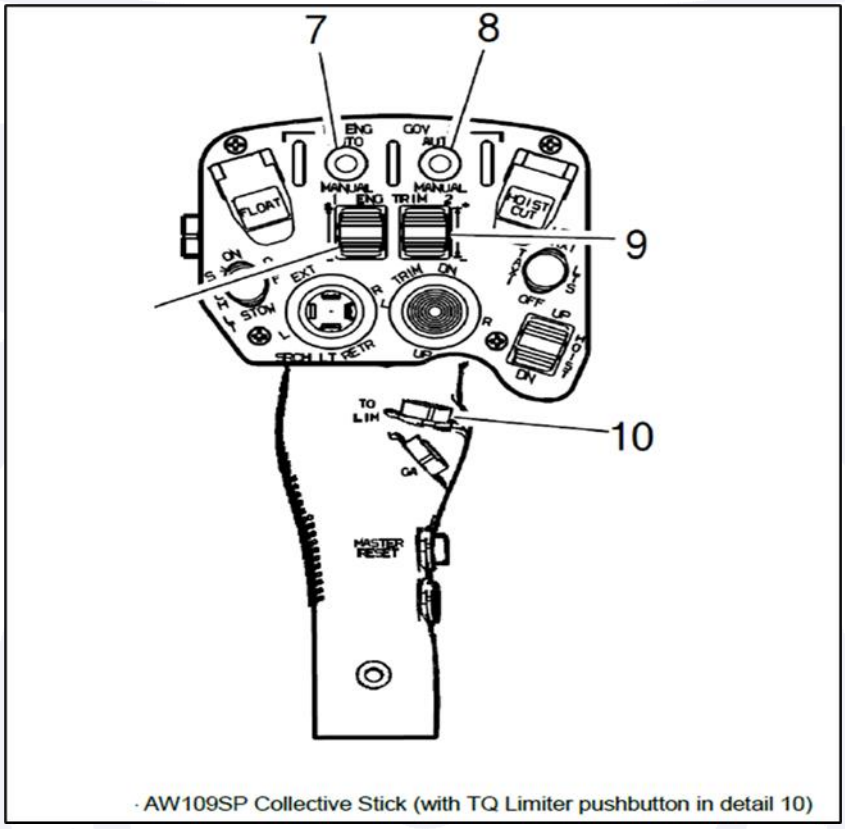


Figure 33 - Collective Stick AW109SP (with TQ Limiter button in detail 10).
Source: Adapted from Section 7 - System Description of the AW109SP RFM.

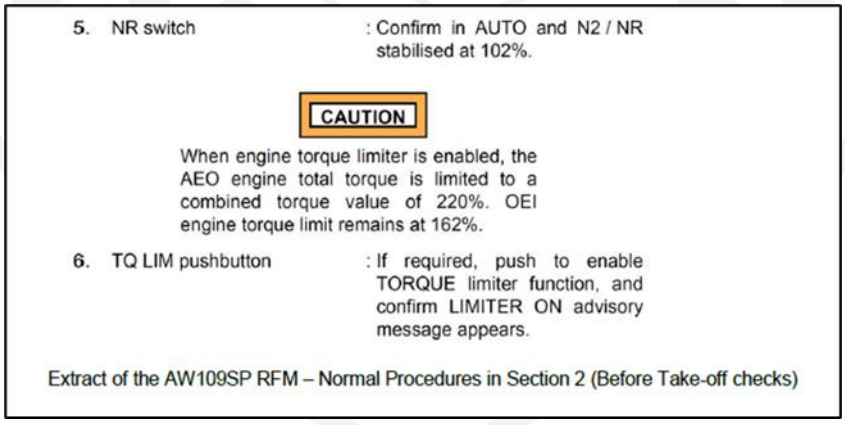


Figure 34 - Before Take-off Checks.
Source: Adapted from Section 2 - Regular Procedures of the AW109SP RFM.

According to Section 1 Limitations of the AW109SP RFM, the Torque Limiter should be activated when the upper flight modes and Flight Director modes are engaged (Figure 35).

COMPANY RESTRICTED

AW109SP RFM Section 1
Document N°109G0040A018 Limitations

GENERAL LIMITATIONS

With AFCS Upper Modes and Flight Director Modes engaged the torque limiter must be active (LIMITER ON advisory message displayed).

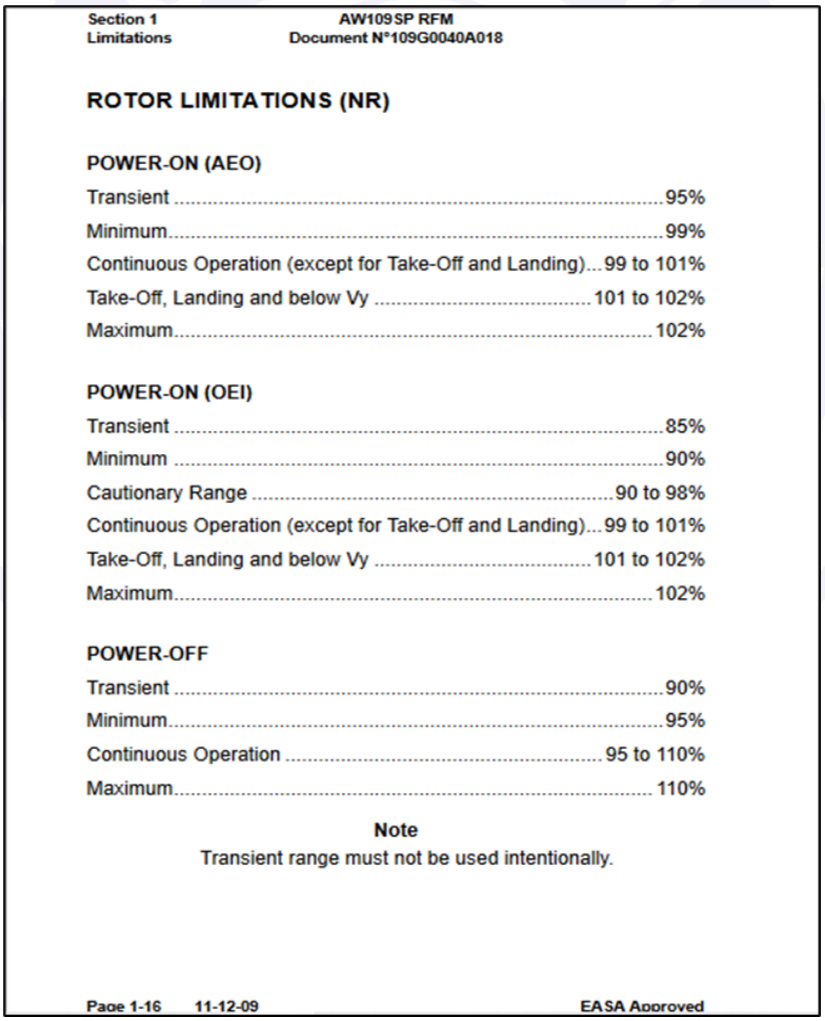
Figure 35 - Extract from the AW109SP RFM - AFCS Limitations in Section 1.

According to the analysis of the DCUs by the engine manufacturer, it was shown that this function was active at the time of impact.

According to data extractions, as soon as the NR dropped below 96%, the message “ROTOR LOW CAS” was probably announced on the panel together with an audible warning.

The data show the recovery of the NR almost immediately, that is, the pilot reacted immediately by lowering the collective from 90.5% to 55.1% in one second.

Next, in Figure 36, extracted from the AW109SP RFM, the rotor limitations (NR) are verified.



Section 1 AW109SP RFM
Limitations Document N°109G0040A018

ROTOR LIMITATIONS (NR)

POWER-ON (AEO)

Transient	95%
Minimum	99%
Continuous Operation (except for Take-Off and Landing)	99 to 101%
Take-Off, Landing and below Vy	101 to 102%
Maximum	102%

POWER-ON (OEI)

Transient	85%
Minimum	90%
Cautionary Range	90 to 98%
Continuous Operation (except for Take-Off and Landing)	99 to 101%
Take-Off, Landing and below Vy	101 to 102%
Maximum	102%

POWER-OFF

Transient	90%
Minimum	95%
Continuous Operation	95 to 110%
Maximum	110%

Note

Transient range must not be used intentionally.

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Figure 36 - Extract from the AW109SP RFM with rotor limitations (NR).

The NR continuously fluctuated between 99% and 100% due to low data resolution.

Figure 37 - Simulation of the beginning of loss of control.

After this period, the vertical velocity of the PT-FPS suddenly and constantly decreased to negative values, until the impact against the ground at 12:23:13 (UTC), with 167 kt of ground speed and 10,000 ft/min of descent rate.

Figure 38 - Impact simulation.

1.19 Additional information.

Regarding the operation of aircraft with cockpits with Digital Full Glass-Cockpit technology, the CENIPA published, in November 2018, the translation of the Flight Safety Study entitled “Introduction of digital electronic displays in small aircraft” prepared by the NTSB, in September 2010, which contained the following comment in its executive summary:

> A review of accidents involving light aircraft equipped with glass cockpit found that pilots' experiences and training in conventional cockpits do not prepare them to safely operate the complex and varied glass cockpit systems that are currently being installed on light aircraft. Furthermore, the lack of information provided to pilots about glass cockpit systems can lead them to misunderstand or misinterpret system failures. As a result, there is a need for new training procedures and tools to ensure that pilots are adequately prepared to safely operate aircraft equipped with glass cockpit avionics.

Still in relation to the study, the item on “previous lessons learned” contained the following comments:

A study by the US Army Aeromedical Research Laboratory in 2001 examined how the switch to glass cockpits on Army aircraft affected real-world security operations. The study analyzed accident rates of four helicopter models with conventional and glass cockpit configurations.

Study results indicated a significantly higher accident rate for the glass cockpit configuration group. The authors suggested that the results provided cause for concern and discussed several possible reasons for the difference, including the possibility that simultaneous mission and equipment changes contributed more to higher accident rates than the cockpit shape. Subsequent research suggested that while pilots preferred the glass cockpit format and believed it improved safety, pilots found it more difficult to learn to use the displays and maintain their efficiency, and they also reported higher workload issues on aircraft with a glass cockpit than in the conventional format.

The new technology has generally reduced workload demands on the crew, but in some cases, the greatest reductions have taken place during times when the workload was already low. In addition, crewmembers began to report that glass cockpit equipment could increase workload during emergencies and times of high demand because they were often forced to reconfigure navigation and in-flight management systems to modify the schedule or get information.

Pilot reports and observational research also identified crew difficulties transitioning to glass cockpit aircraft and, eventually, confusion with operating integrated systems, even among pilots who reported feeling like they understood their systems well. Even before electronic displays became commonplace, informal reports from flight crews, as well as findings from accident investigations, revealed potential problems if pilots relied too much on automated systems or if they did not understand automated system behavior.

The results of that study suggested that the introduction of a glass cockpit did not result in a measurable improvement in flight safety when compared to similar aircraft with conventional instruments. The analysis identified the need for pilots to have sufficient knowledge and proficiency in this equipment to safely operate aircraft equipped with glass cockpit avionics.

1.20 Useful or effective investigation techniques.

Nil.

2. ANALYSIS.

The AW109SP (PT-FPS) aircraft was registered in the TPP category and was operated by *Cristália Prod. Quim. Farmacêuticos* Ltd. since 28JUL2016.

According to the maintenance records, the airframe and engine logbooks were updated. The last inspection of the aircraft, the “50 hours” type, was carried out on 25OCT2018 by the maintenance organization Helipark *Táxi Aéreo e Manutenção Aeronáutica* Ltd., in Carapicuíba - SP, with 5 hours and 22 minutes flown after the inspection. The aircraft CA was valid.

Data captured by the DCUs during the last flight showed that both engines were producing power before the impact and that no indication of failure or malfunction was recorded.

The characteristics of the wreckage evidenced a collision with great angle and great speed.

Due to the sudden loss of power on the 28 VDC bus, there was no recording of fault and exception logs of the volatile memory buffer on the NVM.

Despite the absence of such recording, the flight data recorded in the IDUs were compatible with those expected for the normal operation of flight control systems.

Thus, there were no failure or malfunction conditions of systems and/or components of the aircraft that could have affected their performance or control in flight.

The METARs of SBSJ, SBTA and SBGW indicated precipitation, light rain and light drizzle over these Aerodromes at the time of the accident. Likewise, meteorological RADAR images illustrated precipitation conditions at 12:40 and 12:50 (UTC).

Based on information from the INMET station in Campos do Jordão - SP, the cloud layer's base was calculated at 246 ft.

When gathering data from the various sources of meteorological information, it was found that the minimum ceiling and visibility conditions required for landing and take-off in VFR operations were not in place, in the region and at the time of the accident.

The crewmembers consisted of two pilots, one designated by the operator as Pilot in Command (PIC) and the other as Second in Command (SIC). Four passengers were on board, totaling six people.

After analyzing the Health Inspections of both pilots, as well as the Medical Background Forms, it was found that both were fit for the exercise of air activity without any medical restrictions imposed. Likewise, the reports of toxicological tests indicated that none of the pilots used alcoholic beverages, illicit medication or drugs in the hours before the accident.

There were no issues related to routines and resting times, as well as any personal issues that could negatively affect the crew.

Thus, there was no evidence that physiological or incapacitating considerations affected the crew's performance.

The aircraft was certified for operation with only one pilot. However, according to the safety policy adopted by the operator, all flights were carried out with two pilots.

The SIC was an employee of the company and had all the necessary licenses and ratings to perform the function, being considered qualified.

The PIC was hired, temporarily, to replace another pilot for that operation.

The crew's necessary licenses, qualifications and ratings for the operation of the AW109SP have not been properly verified. According to the survey performed, the operator did not have a competent professional to analyze the pilots' curriculum, and the hiring was made by the indication of the company's own pilots.

According to the data obtained, the PIC did not have the necessary endorsement to operate the AW109SP model aircraft and according to the IS 61-006, revision D, he could only operate the aircraft under instruction.

Regarding the qualifications of the SIC, the Investigation Team had difficulties in tracking his qualification process due to the lack of detail of the instruction required for the endorsement, in IS 61-006, so that the training received by the SIC did not generate supporting records (flight records, evidence, etc.) that could be analyzed by the Investigation Team, thus making it impossible to verify the quality of the instruction received by the endorsee.

The lack of standardization and criteria for the instruction of a highly complex aircraft can impair the effectiveness of pilots' assessments and, consequently, an error in the minimum requirements necessary for qualification in a "class" aircraft, which can lead to hiring or designation of those with disabilities in the minimum necessary skills, compromising flight safety.

It was not possible to identify the position that the pilots were occupying in the cockpit. According to the survey carried out, it was common for the PIC to act as a pilot flying. However, it was not possible to say who was actually in charge at the time of the accident.

It should be noted that, according to the definition contained in the RBAC 01, the PIC would have the final authority and responsibility for the operation and safety of the flight.

Thus, considering that the crew was composed of a Pilot in Command who did not have the minimum qualifications to exercise his prerogatives, it was verified that the operation of the aircraft was conducted below the minimum safety levels established in the aeronautical regulations.

From the recovered data, it was found that the aircraft completed part of the route in VMC and, near Campos do Jordão - SP, it performed a non-certified procedure in IMC.

In this context, the use of an uncertified IFR descent chart did not ensure specific protection against obstacles, up to a position in which the criteria of holding circuit or en-route obstacle clearance criteria applied.

Thus, the decision to proceed with the approach, based on a non-certified procedure, denoted an inadequate assessment of the existing risks in that operation as well as a low adherence to the flight safety assumptions.

According to the uncertified procedure, after reaching the FSIJC point, the aircraft should have headed 300° towards SIJC, descending from 6,700 ft. However, it continued South with an average heading of 205° to 210° and a descent rate between 600-700 ft/min.

As the active flight plan in the FMS was discontinued, the two points FSIJ2 and FSIJC were not connected by a continuous arc.

In this way, the AFCS was directing the helicopter to intercept the next leg of the flight plan (FSIJC-SIJC) without blocking the FSIJC. However, the aircraft proceeded South with an average heading of 205° to 210° and a descent rate of 600-700ft/min until, at one point, it began a steep climb, simultaneously with a constant change of course towards the right and approximately 40º of pitch angle.

When considering such issues, it is possible that the lack of specific knowledge regarding the aircraft model has favored an incorrect performance of the pilot who was operating the helicopter, especially in the use and interpretation of information available in the avionics, since the AW109SP model aircraft had glass cockpit on its dashboard, which the PIC was unfamiliar with.

This hypothesis is corroborated by the aircraft trajectory during the approach, with a heading different from the destination and in constant descent.

In this context, the lack of proficiency in that aircraft model may have contributed to difficulties, on the part of the PIC, in correctly identifying the information available from the flight director and the consequent change of route.

Another issue concerns the fact that the visual annunciators on the aircraft's ADI and HSI were ignored.

As the IMC conditions prevailed around the accident site, the sudden increase in power and attitude of the helicopter could have been caused by a possible visual contact of the pilot with the terrain or by the activation of one of the visual and audible alerts generated by the TAWS, during the descent.

A simulation was used to reconstruct the visual information available in the ADI and HSI. In this simulation, when starting the climb to maximum altitude after a possible visual

contact with the terrain, the crew focused only on the fast climbing, reducing the speed to zero, increasing the torque and, consequently, varying the heading.

In this case, a possible decrease in the level of situational awareness of the crew may have contributed to the fact that important aspects of the flight parameters had not been properly observed during the performance of the procedure.

This situation would have led to a loss of control and lack of support, probably triggering the “ROTOR LOW” message.

The AW109SP RFM determined the use of the Torque Limiter function in cases of operations of the higher AFCS modes.

According to the engine manufacturer's opinion, based on the analysis of the DCUs, the Torque Limiter function was activated in the moments that preceded the accident.

As the PIC was not qualified for this type of aircraft and had experience on the A109E (which had a 3-axis AFCS, without collective control), it is inferred that he did not have the necessary knowledge to use it correctly, as can be observed in the trajectory profile compatible with a manual flight, moments before the collision with the ground. Thus, an automatic FMS command could be disregarded, as its maximum roll rate was 3°/s, while the turn in question, the average variation recorded was above 4.5°/s.

Possibly, the association of the facts presented contributed to a loss of control of the aircraft and the consequent spatial disorientation, with the helicopter crashing into the ground.

3. CONCLUSIONS.

3.1 Facts.

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

b) the airframe and engine logbook records were updated;

c) the aircraft had a valid CA;

d) there was no evidence of failure or malfunction conditions of systems and/or components of the aircraft that could have affected its performance or control in flight;

e) there was no evidence that physiological or incapacitating considerations affected the crew's performance;

f) the pilots had valid CMA;

g) the pilots had valid HMLT and IFRH Ratings;

h) the SIC was qualified and had experience in the aircraft model;

i) on 24APR2016, the AW109SP model aircraft ceased to be a “type” and was classified as a “class”;

j) as of 24APR2016, endorsement was required to operate the AW109SP model aircraft;

k) the PIC did not have the necessary endorsement to operate the AW109SP model aircraft;

l) there were not the minimum ceiling and visibility conditions required for landing and take-off in VFR operations in the region and at the time of the accident;

m) the helicopter was found crashed near the *Pico do Itapeva*, in Campos do Jordão - SP;

n) an uncertified IFR procedure was found next to the wreck;

o) the points relating to the non-certified procedure were included in the FMS;

p) the aircraft was destroyed; and

q) all occupants suffered fatal injuries.

3.2 Contributing factors.

- **Training – undetermined.**

The lack of training required to operate the aircraft may have promoted gaps in knowledge, skills, and attitudes necessary to ensure the correct performance of the PIC during the flight.

These circumstances may have demanded greater cognitive effort to apprehend the conditions required by the equipment as well as may have favored misinterpretations in relation to the instruments and the behavior of the aircraft during the flight.

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

The meteorological conditions present in the destination location were not favorable for a VFR approach, since they entailed visibility restrictions.

- **Crew Resource Management – undetermined.**

The composition of the crew with one of the unqualified members may have contributed to the loss of flight performance and a probable inefficiency in the management of the cabin during the occurrence.

- **Disorientation – a contributor.**

The adverse weather conditions caused visibility restriction and the loss or damage of orientation through the references of the pilot's flying balance organs, providing disorientation and the consequent loss of control of the aircraft.

- **Flight planning – a contributor.**

There was inadequacy in the preparation work performed by the crew for the flight or part of it about carrying out a correct assessment of the meteorological conditions on the route and the use of an uncertified procedure during the approach for landing.

- **Organizational processes – undetermined.**

The lack of verification of the PIC's qualification and experience in the aircraft model reflected flaws in the personnel selection and monitoring processes adopted by the company, which could have allowed the prior identification of the PIC's training needs for that aircraft model.

4. SAFETY RECOMMENDATION.

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

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

Recommendations issued at the publication of this report:

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

A-173/CENIPA/2018 - 01 Issued on 03/23/2023

Evaluate the relevance of clarifying in the table "Multi-engine Helicopters Class", of Appendix B of the IS 61-006, revision J, of 26NOV2021, in force on the date of the publication of this Final Report, that the instruction required for the endorsement of the AW109SP aircraft model must comply with the criteria established in the ANAC Operational Assessment Report for that aircraft.

A-173/CENIPA/2018 - 02 Issued on 03/23/2023

Analyze the feasibility of establishing guidelines on digital electronic displays in their training materials and instructional programs so that pilots are made aware of the importance of theoretical and practical instruction for the operation of glass cockpit aircraft, as well as the difficulties encountered in the transition from operating conventional cabin aircraft to digital electronic display cabins.

A-173/CENIPA/2018 - 03 Issued on 03/23/2023

Disseminate the lessons learned in this investigation to Civil Aviation Training Centers authorized to provide theoretical and/or practical instructions for helicopters, with the objective of contributing to the dissemination of the culture of endorsement, emphasizing its importance for the safe operation of the aircraft.

5. CORRECTIVE OR PREVENTATIVE ACTION ALREADY TAKEN.

In November 2018, the CENIPA published the translation of the Flight Safety Study entitled "Introduction of digital electronic displays in small aircraft" prepared by the NTSB. The Study results identified the need for pilots to have sufficient knowledge and proficiency in this equipment to safely operate aircraft equipped with glass cockpit avionics.

A meeting was held with the ANAC representatives aiming to discuss improvements in the endorsement process. In July 2019, the ANAC published revision E of the IS 61-006, changing the control of endorsements granted by pilots, establishing that, in addition to the endorsement in the CIV, it will also be necessary to register the endorsement in the digital CIV by the endorser, contributing to increase awareness of the need for endorsement, considering that it is possible to increase inspection using electronic support tools.

On March 23th, 2023.