BEA
Bureau d'Enquêtes et d'Analyses
pour la sécurité de l'aviation civile

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SAFETY INVESTIGATION REPORT

Accident to the AIRBUS - EC135- T1 registered F-HJAF operated by SAF HELICOPTERES on 8 December 2020 at Bonvillard (Savoie)

Time	Around 17:15[1]
Operator	SAF HELICOPTERES (France)
Type of flight	Instruction flight
Persons on board	2 pilots, 2 hoist operators, 2 rescuers
Consequences and damage	5 persons fatally injured, 1 person severely injured, helicopter destroyed

Collision with vegetation during an instruction flight in helicopter hoist operations, at night

[1] Except where otherwise indicated, the times in this report are in Coordinated Universal Time (UTC). One hour should be added to obtain the legal time applicable in Metropolitan France on the day of the event.

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December 2022 BEA2020-0523.en

Safety investigations

The BEA is the French Civil Aviation Safety Investigation Authority. Its investigations are conducted with the sole objective of improving aviation safety and are not intended to apportion blame or liabilities.

BEA investigations are independent, separate and conducted without prejudice to any judicial or administrative action that may be taken to determine blame or liability.

SPECIAL FOREWORD TO ENGLISH EDITION

This is a courtesy translation by the BEA of the Final Report on the Safety Investigation. As accurate as the translation may be, the original text in French is the work of reference.

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Contents

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Glossary

Abbreviation	English version	French version
°C	Degree Celsius	
AOC	Air Operator Certificate	
ARCC	Aeronautical Rescue Coordination Centre	
BEA-é	State aviation safety investigation authority	Bureau Enquêtes Accidents pour la sécurité de l'aéronautique d'État
BFG	Good overall operation	Bon Fonctionnement Général
BFU	German Federal Bureau of Aircraft Accident Investigation	Bundesstelle für Flugunfalluntersuchung
CAT	Commercial Air Transport	
CDU	Control Display Unit	
CMM	Compliance Monitoring Manager	
CODIS	Departmental fire and rescue operational centre	Centre Opérationnel Départemental d'Incendie et de Secours
CPL(H)	Commercial Pilot License (Helicopter)	
CRS	Republican security corps	Compagnie Républicaine de Sécurité
CVR	Cockpit Voice Recorder	
DAG	Gendarmery air detachment	Détachement Aérien de la Gendarmerie
DECU	Data Engine Computer Unit	
DGAC	French civil aviation authority	Direction Générale de l'Aviation Civile
DSAC	French civil aviation safety directorate	Direction de la Sécurité de l'Aviation Civile
DSAC-CE	Civil aviation safety directorate - Lyon	Direction de la Sécurité de l'Aviation Civile - Centre Est
EASA	European Aviation Safety Agency	
ECU	Engine Control Unit	
EFIS	Electronic Flight Instruments System	
FDR	Flight Data Recorder	
FI(H)	Flight Instructor (Helicopter)	
FL	Flight Level	
ft	Feet	
GNSS	Global Navigation Satellite System	

Abbreviation	English version	French version
GPS	Global Positioning System	
GTA	Air transport gendarmery	Gendarmerie des Transports Aériens
HEC	Human External Cargo	
HEMS	Helicopter Emergency Medical Service	
HESLO	Helicopter External Sling Load Operations	
HHO	Helicopter Hoist Operation	
HMU	HydroMechanical Unit	
ICAO	International Civil Aviation Organisation	
IMC	Instrument Meteorological Condition	
IR	Instrument Rating	
Kt	Knot	
LC	Line Check	
MCP	Maximum Continuous Power	
METAR	Aerodrome routine meteorological report	
MGB	Main GearBox	
MHz	Mega Hertz	
NDB	Non Directional Beacon	
NF	Free turbine speed	
NG	Gas generator speed	
NM	Nautical Mile	
NO-OH	Operation airworthiness - Helicopter operations	Navigabilité Opération - Opérations Hélicoptères
NPA	Non-Precision Approach	
NPCA	Nominated Person for Continuing Airworthiness	
NPCT	Nominated Person for Crew Training	
NPGO	Nominated Person for Ground Operations	
NPFO	Nominated Person for Flight Operations	
NR	Main rotor speed	
NVG	Night Vision Goggles	
NVIS	Night Vision Imaging System	
OEI	One Engine Inoperative	
OGE	Outside Ground Effect	
OM	Operations Manual	
OPC	Operator Proficiency Check	

Abbreviation	English version	French version
ORO	Organisation Requirements for air Operations	
PFD	Primary Flight Display	
PGHM	High mountain gendarmery squad	Peloton de gendarmerie de haute montagne
PN-EPN	Aircrew - Aircrew expertise	Personnel Navigant – Expertise Personnel Navigant
QNH	Altimeter setting for altitude above sea level	
QRH	Quick Reference Handbook	
SAR	Search And Rescue	
SATER	Air-land rescue	Sauvetage Aéro-Terrestre
SD	Secure Digital	
SIGMET	SIGnificant METeorological Phenomena	
SIGWX	Significant weather chart	
SPA	SPecific Approvals	
SPO	SPecialized Operations	
SRTA	Air transport gendarmery investigation section	Section de Recherche de la gendarmerie du Transport Aérien
T/R	Tail Rotor	
TAF	Terminal Area Forecast	
TCM	Technical Crew Member	
TGB	Tail GearBox	
TLB	Technical Log Book	
TR	Type Rating	
TRE(H)	Type Rating Examiner (Helicopter)	
TRI(H)	Type Rating Instructor (Helicopter)	
UTC	Coordinated Universal Time	
VFR	Visual Flight Rules	
VIS	Visibility	
VMC	Visual Meteorological Conditions	
VOR	VHF Omnidirectional Range	
WINTEM	WINd TEMperature chart	
WU	Warning Unit	

Synopsis

On 8 December 2020, the flight schedule for the EC135 registered F-HJAF, operated by SAF HELICOPTERS involved six training flights: two morning flights, two afternoon flights and two night flights. This training was carried out in the scope of a specific approval for commercial air transport hoist operations (SPA.HHO).

At the end of the afternoon, the two crews held a briefing before the two night flights. The review of the weather forecast had revealed that there would be a disturbance bringing snow in the evening. Given the arrival of this disturbance, the very short exercise programme (three hoist operations) and the proximity of the exercise site (situated at 3.2 NM south-east of the aerodrome at an altitude of 1,820 m), all the persons concerned took the decision to carry out the two flights one after the other and to switch crews with the rotor turning at the end of the first night flight.

For these two night flights, the crew on board was made up of an instructor pilot, a pilot in instruction, an instructor hoist operator, a hoist operator in training and two rescuers who were taking part in the hoist operations.

After the first night flight, the first crew (pilot in instruction and hoist operator in training) was replaced by the second pair. The instructor pilot, the instructor hoist operator and the two rescuers remained on board during this switch over.

The second pilot in instruction took off at 17:00 from Albertville aerodrome bound for the exercise site. Having arrived at the area, the pilot carried out the same exercises as during the previous flight.

Upon completion of the exercises, the pilot flew out of the hover and gained speed on a heading roughly oriented north-west and then initiated a left turn while remaining in level flight. The helicopter headed towards the mountainside, collided with the vegetation, and then with the ground.

The BEA has issued two safety recommendations to SAF HELICOPTERES.

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Organisation of the investigation

The BEA on-duty investigator was informed of the accident to F-HJAF in the early evening of Tuesday, 8 December 2020.

In accordance with Annex 13 to the Convention on International Civil Aviation and European regulation (EU) No 996/2010 on the investigation and prevention of accidents and incidents in civil aviation, a safety investigation was opened by the BEA.

In compliance with the European regulation and international provisions, a German accredited representative (BFU investigator) was associated with the investigation as the representative of the State of Design and State of Manufacture of the helicopter. Technical advisors from SAF HELICOPTERES, Safran Helicopter Engines and Airbus (France and Germany) were also associated with the investigation.

In the morning of Wednesday 9 December, the BEA investigator in charge travelled to Albertville. He was joined in the early afternoon by a team of five BEA agents from the Le Bourget office. Technical advisors from Airbus and Safran Helicopter Engines and two investigators from the State aviation safety investigation authority (BEA-É) then arrived at the end of the afternoon.

On Thursday 10 December, once the weather conditions were favourable for travelling to the site by helicopter, two BEA investigators and two investigators from the Air transport investigation section (SRTA) of the Air transport gendarmery (GTA) went to the accident site under the supervision of the High mountain gendarmery squad (PGHM). During this mission, the two engine computers, the Brite Saver computer and various data recording equipment were removed from the wreckage and taken for analysis. These equipment items were sent to the BEA's premises in Le Bourget on Friday 11 December.

The helicopter wreckage could not be recovered immediately due to the very adverse weather conditions. The snowfalls that followed the accident led to the recovery operation being postponed to the second quarter of 2021.

On 22 April 2021, using the operator's resources, the BEA personnel (aided by the Airbus and SAF HELICOPTERES technical advisors) and the gendarmery jointly recovered the wreckage from the accident site and collected debris in a first sweep of the zone. The wreckage was transported to the BEA for a detailed examination of the airframe and engines.

On 8 June 2021, a team made up of BEA investigators and Airbus Germany technical advisors returned to the accident site to make further observations and to recover debris which had stayed at the site due to the snow coverage.

The computers, airframe and engines along with various elements and equipment recovered at the site were examined at the BEA's premises.

The draft final report was submitted to the German accredited representative and his technical advisor, the operator, BEA-É, the French civil aviation authority (DGAC) and the European Aviation Safety Agency (EASA) for comments.

1 FACTUAL INFORMATION

1.1 History of the flight

On 8 December 2020, the flight schedule for the EC135 registered F-HJAF included six flights: two morning flights, two afternoon flights and two night flights. These flights were part of specific training for helicopter hoist operations for two crews consisting of a pilot and a hoist operator.

Note: the aim of the training delivered during the flights was to instruct the crews in helicopter hoist operations which fall within the scope of a specific approval - the SPA.HHO - in reference to the requirements of Consolidated Regulation EU No 965/2012, known as AIR-OPS[2] (see paragraph 1.17.1). This training was ultimately to enable crews to carry out mountain rescue missions in any type of situation.

Each crew in training took turns performing two day flights and one night flight.

- For the daytime flights, the personnel present on board the helicopter were an instructor pilot, a pilot in instruction, an instructor hoist operator, a hoist operator in training, and a rescuer[3] for hoist operations.
- For the night flights, the personnel present on board the helicopter were an instructor pilot, a pilot in instruction, an instructor hoist operator, a hoist operator in training, and two rescuers for hoist operations.

A briefing before departure and a post-flight review briefing took place for each flight.

At the end of the afternoon, the two crews held a briefing before the two night flights. During the last daytime flight, the instructor and the pilot of the accident flight selected an exercise site in preparation for the night helicopter hoist operations.

Given the disturbance bringing snow forecast for the evening, the very short exercise programme (three hoist operations at 20-25 m during a flight of approximately 30 min) and the proximity of the exercise site, the instructor, in consultation with the crews concerned, decided to carry enough fuel to perform both flights one after the other, and to switch crews in Albertville with the rotor turning at the end of the first night flight.

[2] Commission Regulation of 5 October 2012 laying down technical requirements and administrative procedures related to air operations (Version in force on the day of the accident).

[3] The rescuers participating in the training were police officers from the National Police assigned to the Alps detachment of the Republican security corps (CRS).

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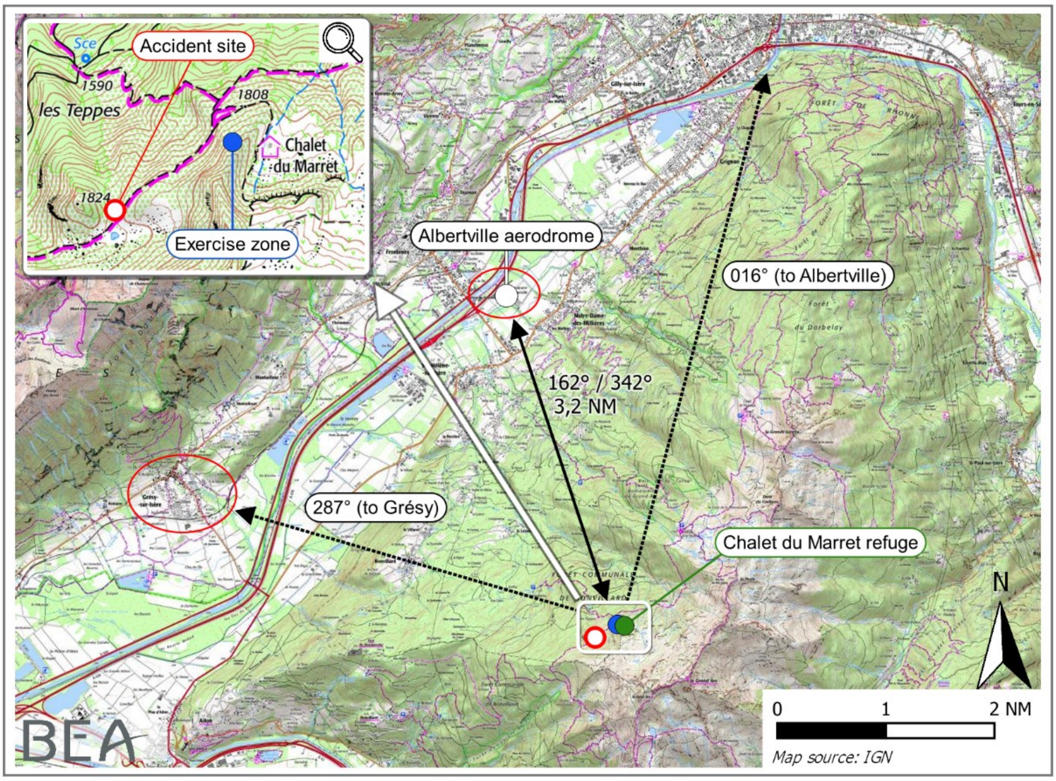

Figure 1: general map of region

At 16:25[4], the first pilot in instruction was at the controls. He took off from Albertville aerodrome and headed south-east towards the exercise site located at 3.2 NM on a radial of 162° with respect to the aerodrome and at an altitude of 1,820 m.

After a reconnaissance of the area, the pilot carried out the three hoist operations. Each hoist operation was preceded by a left-hand racetrack to put the helicopter in hover facing south-east. The first two hoist operations set down the two rescuers (one per hoist operation). The third hoist operation hoisted on board the two rescuers together.

The three hoist operations were carried out by the hoist operator in training supervised by the instructor hoist operator. Afterwards, at the instructor's request, the pilot landed near the *Chalet du Marret* refuge[5]. He then flew out of the exercise area heading towards Albertville (the town) and descended towards the aerodrome. The pilot landed in front of the SAF HELICOPTERES hangars at 16:55. The crews (pilot in instruction and hoist operator in training) switched with the rotor turning while the instructor pilot, the instructor hoist operator and the two rescuers remained on board.

The second pilot in instruction took off at 17:00 from Albertville aerodrome bound for the exercise site. On the way to the site, the instructor identified fog banks on the northern slope of the mountain located to the north-east of the exercise site. On arriving at the zone, the pilot carried out the same exercises as during the previous flight.

[4] The aeronautical night (30 min after sunset) started at 16:22 at Chambéry.

[5] Unguarded refuge (usable by hikers), not occupied during the event.

The recorded flight path showed that the pilot flying then flew out of the hover. He headed north-west, gained speed and then made a left-hand turn by around 180° while staying in level flight. The helicopter headed towards the mountainside. The main rotor blades hit the top of a first row of conifers. The airframe of the helicopter then collided head-on with a second row of trees, then with the snow-covered ground. During this second collision, the instructor pilot in the front left seat was ejected from the helicopter and fell into the snow. Although severely injured, he managed to telephone the SAF HELICOPTERES operations department and inform them of the accident.

1.2 Injuries to persons

	Injuries		
	Fatal	Serious	Minor/None
Crew	5	1	0
Passengers	0	0	0
Others	0	0	0

1.3 Damage to aircraft

The helicopter collided with the top of a first row of conifers, then passed through a second row of trees located about 50 m ahead, before colliding with the ground 50 m further on.

The combination of these three impacts (with the vegetation then with the ground) led to the total destruction of the helicopter.

1.4 Other damage

Not applicable.

1.5 Personnel information

For these two night instruction flights, the crew on board was made up of: in the cockpit, an instructor pilot and a pilot in instruction; and in the cargo area, a hoist operator in training, an instructor hoist operator, and two rescuers who were taking part in the exercises.

1.5.1 Instructor pilot, pilot-in-command

Male, aged 50, French nationality.

Licence and medical fitness

- (Military) helicopter pilot certificate obtained in 1993.
- CPL(H) licence obtained on 2 February 2011 by converting the Commercial Pilot Licence obtained in 2003.
- Class 1 medical fitness certificate valid up to 1 January 2021 or 1 July 2021, depending on the type of commercial operation[6].

[6] Single pilot or two-pilot crew.

Ratings

- First Type Rating (TR) on AS350 obtained in 1999.
- TR on AS350 valid up to 31 October 2020.
- TR on EC145/BK117 obtained in 2007 and valid up to 31 January 2021.
- TR on EC135/635 SP obtained in 2008 and valid up to 31 May 2021.
- Night rating (helicopter) obtained in June 2014.

Instructor ratings

- Flight Instructor - Helicopter rating (FI(H)) valid up to 31 October 2022.
- Type Rating Instructor (TRI(H)) valid up to 31 October 2022.
- Type Rating Examiner (TRE(H)) valid up to 30 November 2021.

Experience as on 7 December 2020

- Total experience: 6,200 flight hours, 3,000 h of which as an instructor.
- On type EC135: 1,513 flight hours, 1,350 h of which as an instructor.
- Hoist operations: More than 5,000.
- Night flight: approximately 1,000 flight hours, 850 h of which using Night Vision Goggles (NVG).
- In the previous three months: 30 flight hours, 2 h and 45 min in night flight, 9 night landings, 64 hoist operations, 10 of which at night[7].

Professional experience

The instructor, who was a former Gendarmery pilot, had been recruited by SAF HELICOPTERES in the summer of 2020. He had spent almost all of his career in the Gendarmery, in which he had had the following responsibilities as manager:

- Planning and running helicopter crew training actions, including high mountain flying and hoisting operations.
- Developing and running new training courses, including NVG flight training.
- Conducting technical and operational crew checks.
- Flight safety.

In addition to his functions as pilot and instructor within SAF HELICOPTERES since August 2020, he was also the Nominated Person for Crew Training (NPCT). He was in charge of implementing and arranging training to obtain the specific approval for helicopter hoist operations (see paragraph 1.17.1).

The pilot was not employed by SAF HELICOPTERES to carry out specialised operations (SPO).

1.5.2 Pilot in instruction

Male, aged 46, French nationality.

Licence and medical fitness

- CPL(H) licence issued on 18 August 2011 to replace a Professional Pilot Licence - Helicopters obtained in 2004.

[7] In the scope of the training to become a SPA.HHO primo instructor.

- Class 1 medical fitness certificate valid up to 6 April 2021 or 6 October 2021 depending on the type of commercial operation.

Ratings

- First TR on AS350 obtained in 2005.
- TR on AS350/EC130 valid up to 31 May 2021.
- TR on EC135/635 SP obtained in 2008 and valid up to 31 December 2020.
- Night rating (helicopter) obtained in February 2012.

Experience as on 7 December 2020

- Total experience: 5,493 flight hours, of which 5,365 hours as pilot-in-command.
- On type EC135: 661 flight hours, of which 659 hours as pilot-in-command.
- Hoist operations: 251.
- Night flight: 63 h and 385 night landings.
- The last night Operator Proficiency Check (OPC) was performed on 25 November 2020[8] under the supervision of the NPCT.
- In the previous three months (according to SAF HELICOPTERES activity list): 116 h and 30 min of night flight, 3 night landings, 7 hoist operations.

The examination of the pilot's last logbook showed that he was in the habit of only completing one line per day of flight with the total number of flight hours performed and the activity carried out during the day. The last information logged in the pilot's logbook was dated 7 September 2020.

Over the previous three years, the pilot had taken part in three mountain rescue seasons (December to March/April). During these three periods, the pilot carried out 205 hoist operations on the EC135-T1, including 57 in training and 148 during mountain rescue missions. Twenty-eight missions had ended at night and five had involved hoist operations. The night flight time for each of these five missions had been 10 to 20 min, which could correspond to the time needed to return to the Courchevel base. It is therefore unlikely that night hoist operations had been carried out during these five missions.

SAF HELICOPTERES indicated that although several mountain rescue missions initiated at the end of the day had finished with a return night flight, there had been no night hoist operations and no night mission had been initiated.

Professional experience

The pilot had been employed by SAF HELICOPTERES for several years. As part of the SPO in which the company was engaged, he was authorised for mountain rescue operations (Courchevel and La Plagne area), Helicopter Emergency Medical Service (HEMS) operations, flight in plain and mountainous areas, Helicopter External Sling Load Operations (HESLO[9] 1 to 4), Human External Cargo operations (HEC[10] 1 and 2) and parachute dropping.

[8] This flight was made with a waxing moon between the first quarter and full moon, rising at 15:21 and setting at 02:48. The associated luminosity was 78% of the luminosity of a full moon. On 8 December, the moon was not visible and there was no moon luminosity.

[9] Helicopter External Sling Load Operation.

[10] Human External Cargo.

1.5.3 Instructor hoist operator

41-year-old male.
He was employed by SAF HELICOPTERES and held the Technical Crew Member (TCM) rating as well as the SPA.HHO (TCM) instructor rating.

Since July 2020, he was the company's Nominated Person for Flight Operations (NPFO) and operations director. He had taken part in the creation of the SPA.HHO (pilot and TCM) training programme with the NPCT. He was an instructor in the SPA.HHO (TCM) theoretical and practical training programme. During the flights, he supervised the hoist operators in training.

1.5.4 Hoist operator in training

49-year-old male.
He was in the process of being recruited by SAF HELICOPTERES. This recruitment was subject to the successful completion of the SPA.HHO (TCM) training programme.

1.5.5 Rescuers taking part in the hoist exercises

The two rescuers belonged to the Alps detachment of the CRS based at Albertville. They were trained in mountain rescue and helicopter hoist operations and took part in the crew training flights as part of the collaboration with SAF HELICOPTERES in preparation for the activation of the Savoie winter mountain rescue plan.

1.6 Aircraft information

The EC135-T1 is certified for day and night VFR flights and single-pilot operations. Flight in known icing conditions and aerobatic manoeuvres are not permitted. The helicopter is classified as non-complex as defined by the AIR.OPS regulation. The maximum permissible take-off weight of the EC135-T1 is 2,835 kg.

The helicopter registered F-HJAF was equipped with a hoist attached to the left side, a landing light and a swivelling searchlight which could be controlled from the two front seats.

1.6.1 Airframe

<table>
<tr><td>Manufacturer</td><td colspan="3">EUROCOPTER</td></tr>
<tr><td>Type</td><td colspan="3">EC135 - T1</td></tr>
<tr><td>Serial number</td><td colspan="3">0044</td></tr>
<tr><td>Registration</td><td colspan="3">F-HJAF</td></tr>
<tr><td>Entry into service</td><td colspan="3">1998</td></tr>
<tr><td>Certificate of Airworthiness</td><td>129122</td><td colspan="2">From 23 September 2013</td></tr>
<tr><td>Airworthiness review certificate</td><td>129122004217344</td><td>From 21 May 2019</td><td>to 13 December 2020</td></tr>
<tr><td>Operation as on 8 December 2020</td><td colspan="3">8,091 h</td></tr>
<tr><td>Owner</td><td colspan="3">SAF HELICOPTERES</td></tr>
<tr><td>Operator</td><td colspan="3">SAF HELICOPTERES</td></tr>
</table>

1.6.2 Engines and Digital Engine Control Units (DECU)

	Engine No 1	Engine No 2
Manufacturer	SHE	SHE
Type	Arrius 2B1A-1	Arrius 2B1A-1
Serial number	30206	30045
Total operating time on 8 December 2020	7,295 h	7,263 h

	DECU No. 1	DECU No. 2
Part number	70EMH01070	70EMH01070
Serial number	6ALD0133CE	6ALD0116CE

1.6.3 Technical Log Book (TLB)

Daily flight monitoring for each helicopter is performed through a Technical Log Book (TLB). The TLB allows a crew to accept an aircraft, to know about maintenance operations, the failure history, calendar and/or time limits and the remaining time between scheduled maintenance inspections. The crew completes the TLB prior to the flight and after the pre-flight inspection, the pilot-in-command normally signs it (in this case the instructor of the flights of 8 December 2020). The names of the pilots, the departure aerodrome, the type of mission and the quantity of fuel on board are logged before starting each flight.

At the end of a flight, the pilot-in-command records the arrival aerodrome, the duration of the flight, the number of start-ups, landings, hoist and sling load operations, the remaining fuel, as well as any failures or faults that occurred during the flight.

The information recorded in the F-HJAF TLB for the day of 8 December indicated the following:

- The logbook had been signed by the pilots in training for each flight.
- The type of mission had been identified as training.
- The times recorded were local.
- During flight No 2, an off-airfield landing had been made with a complete engine shut-down.
- During the first five flights, no failure or anomaly was recorded by the pilots who noted BFG[11].

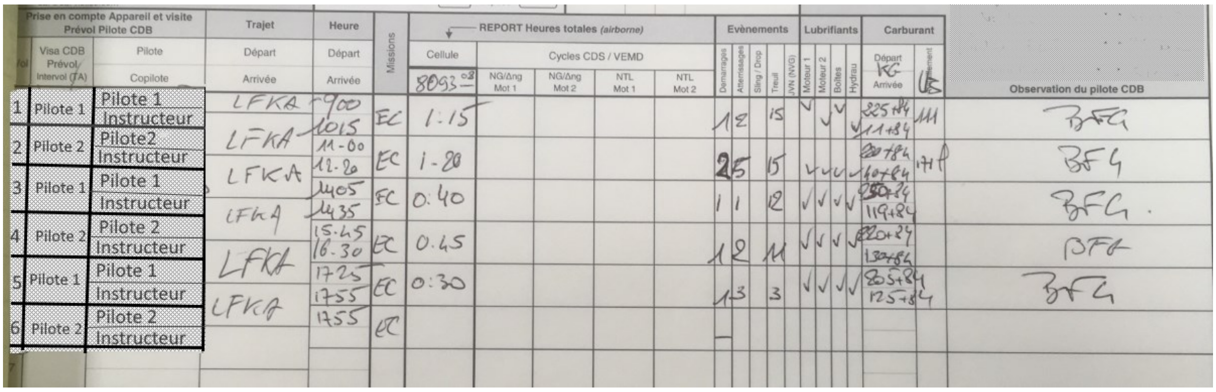

Figure 2: F-HJAF TLB (anonymised excerpt)

[11] Good overall performance.

1.6.4 Helicopter operating procedures

The Operations Manual (OM) Part B contains the Quick Reference Handbook (QRH) procedures for each type of helicopter operated by SAF HELICOPTERES. The QRH contains the information from the Flight Manual as well as the specific provisions in force in the company for helicopter operations.

The QRH for the EC135-T1 powered by two Arrius 2B1A_1 engines (applicable to F-HJAF) had been revised (revision No 4) on 13 November 2020 in order to introduce the procedures specifically associated with helicopter hoist operations (SPA.HHO).

1.6.5 Weight and balance, performance

The investigation revealed that for the accident flight, the helicopter's weight and balance values were within the flight envelope and the operational limitations defined by the Flight Manual and the OM of the company.

In temperature conditions of 5°C maximum, the helicopter had the necessary performance capability to remain in hover Out of Ground Effect (OGE) at its maximum weight up to 7,000 ft. Given the fuel used during the first night flight, this limitation increased to 8,000 ft for the second flight.

The helicopter configuration was a variant dedicated to mountain rescue. In this configuration, only the rear right seat had been retained in the cargo area. A lifeline had been added to the floor of the cargo area to allow personnel in this area to secure themselves when the side door was opened in flight during hoist operations.

The "weight and balance" section of the QRH for the EC135-T1 powered by two Arrius 2B1A_1 engines includes a chart used to determine the weight and balance depending on the quantity of fuel on board, without any further calculation, based on 10 possible configurations. As the helicopter configuration used on the day of the accident did not match any of the 10 planned configurations, a weight and balance sheet had to be drawn up for the flights. However, the performance charts in the QRH could still be used if a weight and balance sheet had been prepared for this configuration and if the temperature conditions were known.

According to the instructor's statement, the weight and balance sheet had been drawn up for both night flights and was present on board the helicopter in a flame-retardant pouch (this sheet was not found at the accident site).

1.6.6 F-HJAF equipment

The EC135-T1 registered F-HJAF was equipped with conventional (analogue) avionics, it did not have Electronic Flight Instrument Systems (EFIS)[12]. The helicopter was not equipped with an autopilot.

[12] Electronic Flight Instruments System.

Figure 3: instrument panel of an EC135-T1 similar to F-HJAF (source: BEA)

The helicopter was equipped with several computers to manage and monitor the engines, fuel, electrical power systems, and failures of the onboard systems.

On the SAF HELICOPTERES EC135s, other systems had been added on the centre console and on the console located under the instrument panel (between the two pilot seats):

- A Data Tracking System (DTS)[13]: a GNSS computer which sends the position of the helicopter to a ground station every minute, allowing SAF HELICOPTERES to know in real-time the position of its fleet equipped with this system.
- A Brite Saver: a computer which records engine and flight parameters for maintenance purposes.
- A HELIMAP: a navigation system consisting of a control unit and a screen displaying the position of the aircraft on a base map.
- A GNSS computer manufactured by Trimble, connected to the HELIMAP system.

The HELIMAP displays on an ICAO VFR map (to a scale of 1:500,000), the position of the helicopter transmitted by the Trimble GNSS computer. This system provides functionalities that include allowing users to define specific points, routes, waypoints, and to display the flight path. According to the statements gathered, given the missions carried out by SAF HELICOPTERES pilots, mainly under daytime VFR conditions, and the lack of details on the base map provided, this system was almost never used.

1.6.7 Limitations

F-HJAF had received an authorisation from the Civil aviation safety directorate - Lyon (DSAC-CE) on 4 December 2020 to carry out helicopter hoist operations under day and night VFR conditions, along with the regulatory waiver CAT.POL.H.305 “Operations without an assured safe forced landing capability”. This regulatory waiver associated with helicopter hoist operations (classified as high risk) eliminates the need to have an One Engine Inoperative (OEI) hover capability during a hoist operation; however, a specific related procedure (diversion in event of engine failure during hoist operation) is required.

[13] Data Tracking System.

1.7 Meteorological information

1.7.1 Weather forecasts available during preparation of night flights

In accordance with the OM, the flight file was compiled by the pilots prior to the first night flight (at 16:05) with the up-to-date information applicable at that time. This file contained the messages from the surrounding aerodromes (16:00 METAR report and 14:00 TAF forecast), the 15:00 and 18:00 SIGWX and WINTEM charts and the SIGMET messages.

The second pilot in instruction and the instructor indicated to the BEA that the weather file information was supplemented by:

- Weather forecasts consulted on applications installed on their smartphone.
- Their visual observations from Albertville aerodrome.
- The Météo-France Savoie weather bulletin published by the Bourg-Saint-Maurice met office (not filed) and consulted by the crews on their smartphones at around 16:00, prior to the first night flight. This bulletin indicated deteriorating weather conditions for the early evening.

METAR and TAF messages (stations located in the region)

Chambéry - Aix-les-Bains aerodrome (ICAO code: LFLB)
The 16:00 METAR indicated variable wind of 2 kt, visibility greater than 10 km, broken clouds at 4,600 ft and 7,200 ft, a temperature of 6°C, a dew point temperature of 2°C, a QNH of 1002 hPa with, temporarily visibility reduced to 4 km, rain and broken clouds at 1,400 ft.

The 14:00 LONG TAF forecast:

- From 8 December at 15:00 to 9 December at 15:00, wind from 360° of 6 kt, visibility greater than 10 km, broken clouds at 3,500 ft.
- Temporarily on 8 December between 16:00 and 23:00, snow showers, broken clouds at 900 ft.
- A change on 9 December between 00:00 and 02:00 to broken clouds at 1,400 ft.
- Temporarily from 8 December at 23:00 to 9 December at 09:00, visibility of 1.5 km, snow, overcast at 400 ft.
- A change on 9 December between 12:00 and 15:00 to scattered clouds at 2,500 ft.

Annecy-Meythet aerodrome (LFLP)
The 16:00 METAR indicated wind from 290° of 2 kt, visibility greater than 10 km, scattered clouds at 3,500 ft and overcast at 5,600 ft, a temperature of 5°C, a dew point temperature of 2°C, a QNH of 1001 hPa with, temporarily visibility reduced to 4 km, rain and broken clouds at 900 ft.

Grenoble-Isère aerodrome (LFLS)
The 16:00 METAR indicated wind from 320° of 7 kt, the direction of which could vary between 290° and 350°, visibility 8 km, rain, broken clouds at 1,900 ft and 2,400 ft, overcast at 3,000 ft, a temperature of 5°C, a dew point temperature of 4°C, a QNH of 1001 hPa with, temporarily visibility reduced to 4 km, rain and broken clouds at 800 ft.

Lyon Saint-Exupéry airport (LFLL)

The 16:00 METAR indicated wind from 340° of 7 kt, visibility greater than 10 km, rain, broken clouds at 3,000 ft and 4,000 ft, a temperature of 6°C, a dew point temperature of 4°C, a QNH of 1002 hPa with, temporarily broken clouds at 1,200 ft and overcast at 2,000 ft.

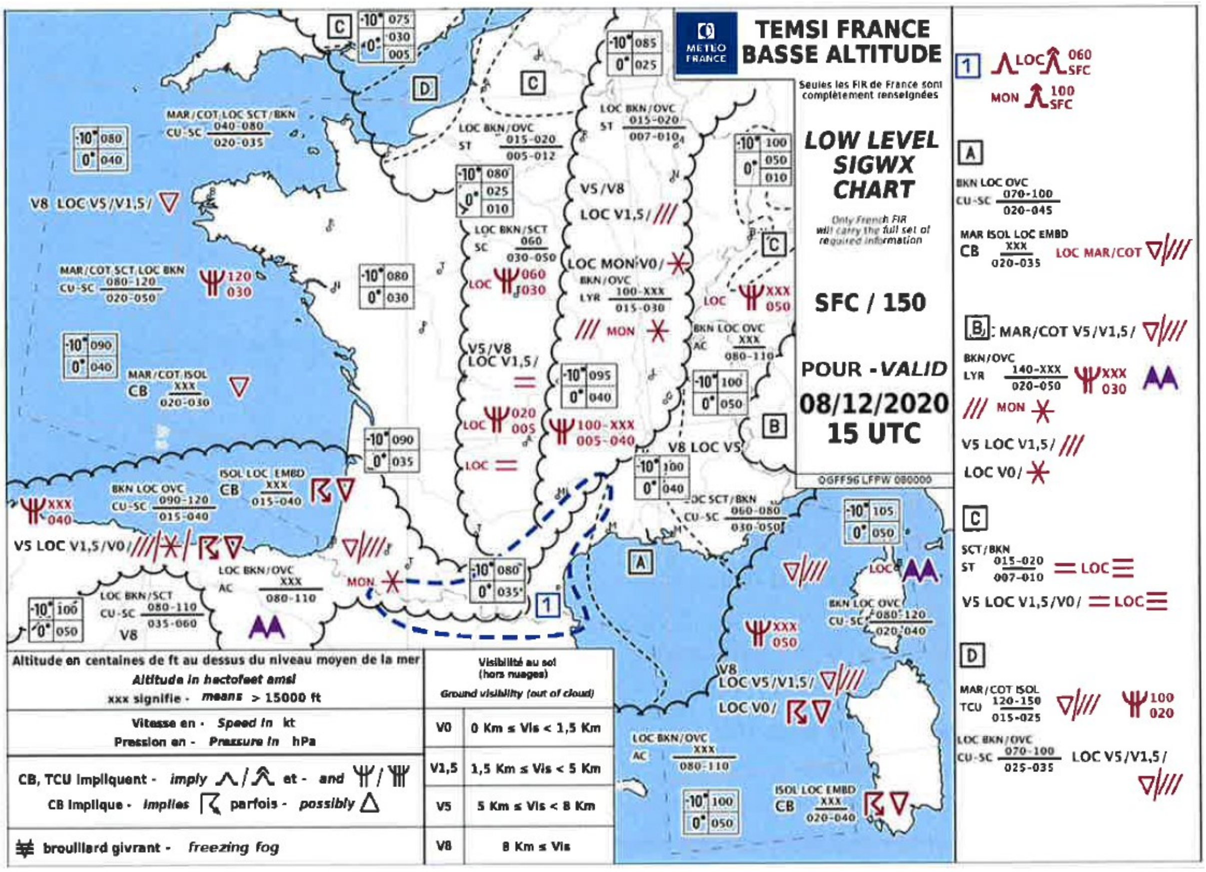

Figure 4: 15:00 SIGWX chart (source: Météo-France)

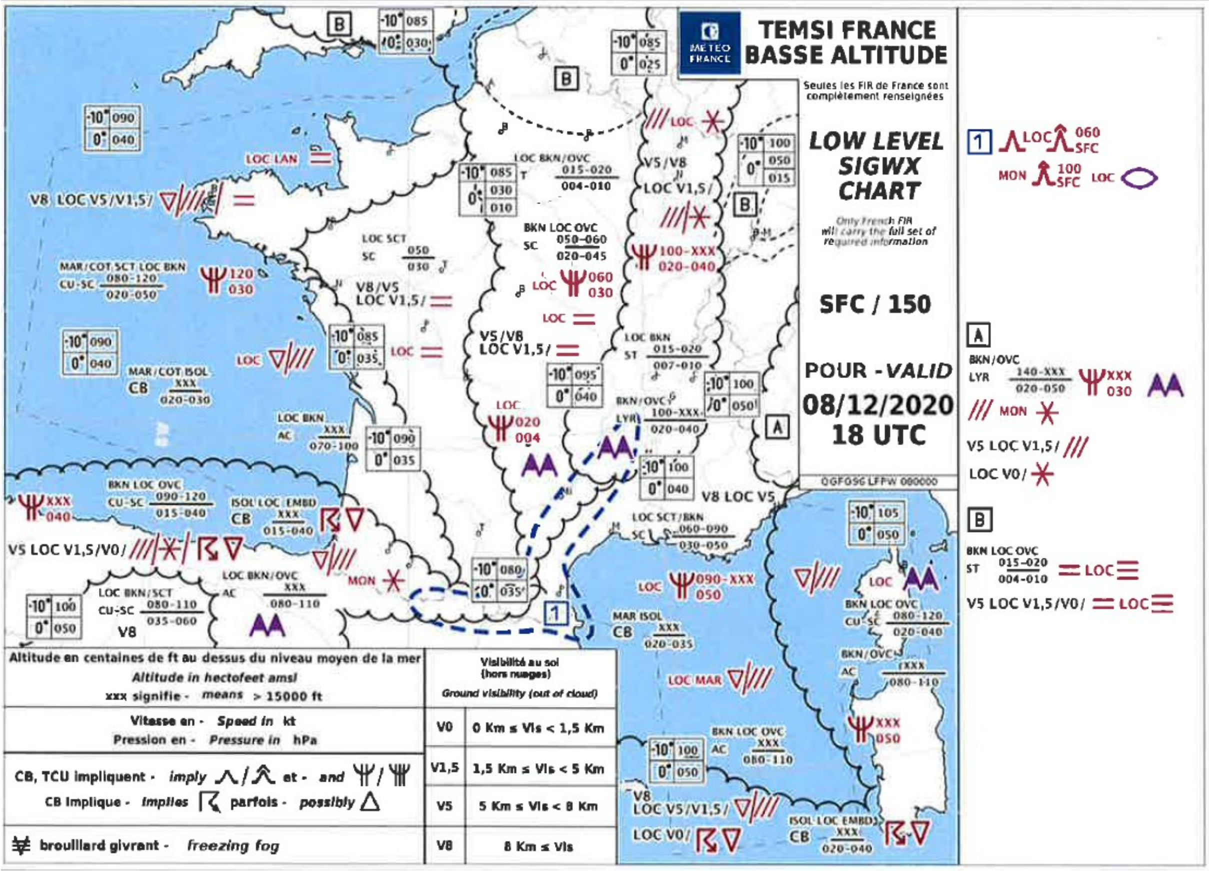

Figure 5: 18:00 SIGWX chart (source: Météo-France)

The 15:00 and 18:00 SIGWX charts showed that a rain/snow disturbance with an area of moderate icing was moving eastwards. At 15:00, the front of this disturbance was expected to affect the Chambéry region, and at 18:00, the Albertville region was also expected to be affected. Broken to overcast altocumulus clouds with a base between 8,000 and 11,000 ft were forecast ahead of this disturbance.

1.7.2 Observations made before and during accident flight

LFLB METAR

The 16:30 METAR indicated variable wind of 2 kt, visibility greater than 10 km, overcast at 4,200 ft, a temperature of 6°C, a dew point temperature of 3°C, a QNH of 1002 hPa with, temporarily visibility reduced to 4 km, rain and broken clouds at 1,400 ft.

The 17:00 METAR indicated wind from 020° of 5 kt, visibility greater than 10 km, overcast at 4,300 ft, a temperature of 6°C, a dew point temperature of 3°C, a QNH of 1003 hPa with, temporarily visibility reduced to 4 km, rain and broken clouds at 1,400 ft.

The 17:30 METAR indicated wind from 010° of 6 kt, visibility greater than 10 km, rain, broken clouds at 4,100 ft and overcast at 4,700 ft, a temperature of 6°C, a dew point temperature of 3°C, a QNH of 1003 hPa with, temporarily visibility reduced to 4 km, rain and broken clouds at 1,400 ft.

Observations made by the pilot of the first night flight and the instructor
Before taking off for the first night flight, the Grand Arc massif was clear and the summits were visible from Albertville aerodrome. High altitude clouds were nevertheless present over the massif.

During the flight between 16:25 and 16:55, a clearly visible partial cloud layer covered the upper ridges of the Grand Arc massif at an altitude of approximately 2,300 m. After the two rescuers had been hoisted on board during the third hoist operation, as the side door was being closed, the pilot noticed that the inner side of the canopy was misting up. He opened the clear-vision window and activated the cabin heating system, which dissipated the mist. At the end of the exercise at around 16:50, the lights of the nearby urban areas were clearly visible and identifiable and made it possible to reach Albertville aerodrome without difficulty.

Observations made during the accident night flight
The following observations are based on the instructor's statement:

- During the flight to the exercise site, fractus clouds were detected on the north face of the mountain situated north-east of the exercise site but did not interfere with it.
- The halos which had formed around the town lights in the valley indicated the presence of humidity.
- During the hoist exercise, the visibility conditions were correct.
- After the accident, when the instructor gave the alert, stars were visible overhead his position.
- Approximately 30 min later, the sky was completely overcast and no stars were visible.

1.7.3 Data recorded during the accident flight

Outside air temperature measurements were retrieved from the data recorded by the Brite Saver of F-HJAF:

Corrected time	Value	Position of helicopter during measurement
16:23	5.6°C	On the ground at Albertville aerodrome
16:33	-0.8°C	Overhead the exercise area (start of exercise)
16:48	-0.7°C	Overhead the exercise area (end of exercise)
16:56	5.7°C	On the ground at Albertville aerodrome
17:07	0.4°C	Overhead the exercise area (start of exercise)
17:15	-0.8°C	Overhead the exercise area (end of exercise)

1.7.4 Meteorological situation (source: Météo-France)

The French met office, Météo-France, was contacted following the accident to produce an analysis of the meteorological situation in the region and at the accident area. Their analysis was based on the information recorded by the surrounding stations, the satellite observations, as well as digital modelling based on forecast data.

General conditions in the region
The weather was disturbed with a cold front passing over the Alps during the evening. The rain/snow limit, which was at an altitude of approximately 1,200 m, dropped to an altitude of 800 m at the end of the afternoon, and then to an altitude of 400 m in the evening as the cold front crossed the region.

Estimated meteorological situation at the time of the accident
The meteorological situation estimated by Météo-France based on forecast models of the zone was as follows:

- Cloud cover: very cloudy to overcast sky, with a ceiling at around 1,400 m and as low as 1,000 m near high terrain.
- Phenomena: snow shower locally on high terrain at around 1,000 m, dropping to approximately 400 m during the night. Icing conditions at around 1,400 m in the afternoon, dropping to approximately 900-1,000 m in the evening.
- Visibility: greater than 10 km, reduced under the snow showers.
- Mean wind: north, light (1 kt).
- QNH: 1003 hPa.
- Situation at altitude: north-west to north wind of 5 to 10 kt at FL020 and FL050.

Satellite observations
The colour composition of the satellite images recorded between 16:00 and 17:30 (see Appendix 7: Satellite charts from 16:00 to 17:30) shows the disturbance progressing from west to east. At 16:00, the disturbance with low clouds (in yellow/ochre) was located in the region of Chambéry. Further east and ahead of this disturbance, the satellite image shows a white area surrounded by a blue area corresponding to high altitude clouds.

The white area may correspond to high altitude stratus or to the reflection of snow on high terrain. Between 16:30 and 17:30, the disturbance can be seen to progress and gradually affect the accident area. In this area, the white shade fades and becomes more and more yellowish; this corresponds to the presence of lower and lower altitude stratus clouds and confirms the gradually deteriorating weather conditions. However, the resolution of the satellite image is not sufficient to determine the proportion of clouds that were present.

1.7.5 Light conditions during the two night flights

During the first night flight, the pilot in instruction took off from Albertville aerodrome at the start of the aeronautical night, but with residual dusk light still present. As the pilot gained altitude, the apparent angle of the sun's disc below the horizon decreased[14] and as a result, there was ambient light again, which allowed him to distinguish the surrounding terrain and detect the possible presence of low clouds, despite the fact that it was a moonless night. In Metropolitan France, the duration of dusk varies throughout the year and lasts between 30 and 40 min.

During the second night flight, i.e. 35 min after the start of the aeronautical night (one hour and five minutes after sunset), given the altitude of the exercise site, the pilot did not benefit from the same phenomenon. Although the town lights in the distance were visible, they were only sufficient for choosing a heading or determining a position with respect to remote reference points. The dark, moonless night would have made it difficult for nearby terrain to be discerned. The helicopter lights, while manoeuvring at low speed or in near-hover were needed to distinguish and avoid obstacles close to hand.

[14] By climbing to a sufficiently high altitude, it is possible to "see" the sun reappear to the west on the horizon and then set again.

1.8 Aids to navigation

For the accident flight, no conventional radio navigation equipment (NDB, VOR) present in the region was usable due to the mountainous terrain forming a screen.

1.9 Communications

The helicopter was operating in uncontrolled airspace. There was no radio exchange with a control unit during the accident flight, nor during the previous night flight.

According to the statements made by the pilot of the previous flight and the instructor, the only radio exchanges made during the two night flights were those made over the A/A frequency (123.5 Mhz) during the take-off and landing phases at Albertville aerodrome. This frequency is not recorded.

1.10 Aerodrome information

Albertville aerodrome (LFKA) is a restricted-use, uncontrolled aerodrome, not approved for night VFR flights. During the aeronautical night, the aerodrome is closed.

In January 1998, the DSAC-CE authorised SAF HELICOPTERES to use the helicopter landing surfaces located in front of the company's hangars during the aeronautical night and the aerodrome closing hours.

1.11 Flight recorders

1.11.1 Regulatory recorders

The helicopter was not equipped with flight recorders such as a CVR or a FDR. It is not a regulatory requirement.

1.11.2 Other recordings

The helicopter was equipped with several computers to manage and monitor the engines, fuel, electrical power systems, and failures of the onboard systems. Certain computers recorded data for maintenance purposes.

The following computers were removed from the helicopter wreckage for analysis:

- Warning Unit (WU): warning panel that indicates emergency situations by means of aural and light warnings An internal memory records the last 31 warning status changes (activation/deactivation). No useful data could be retrieved for the investigation.
- Cockpit Display Unit (CDU): computer that displays key engine, fuel and electrical parameters, as well as CAUTION indications. The damage to the CDU meant that no useful data useful for the investigation could be retrieved.
- Data Tracking System (DTS): If an SD card is inserted in the front panel of the DTS, the positions are recorded every second. The DTS does not have an internal memory recording the position parameters. The only positions that could be retrieved were those received by the operator.
- Engine Control Unit (ECU): digital computer that governs the fuel flow and manages the parameters for an engine. Failure information and its context are recorded in a non-volatile memory. There were two ECUs on this helicopter, one per engine. The data from both computers was retrieved and synchronised to the nearest second (see paragraph 1.16.1.1).

- Brite Saver: its data was recorded on an SD card inserted in the front panel and in an internal memory of the computer. The two night flights (accident flight and previous flight with crew switching while the rotor was turning) were not recorded on the SD card. The internal memory of the Brite Saver recorded both night flights (see paragraph 1.16.1.2).

An SD card was also found in the wreckage. This SD card had a label indicating that it contained data pertaining to the DTS. It did not contain information pertaining to the event flight (the most recent files were from 2014).

1.12 Site and wreckage information

1.12.1 Accident site

The BEA investigators were only able to reach the accident site two days after the event due to the adverse weather conditions. They were set down by a Gendarmery helicopter. Between the time of the accident and the first visual examination of the site, a significant amount of snow had fallen on and around the wreckage.

The accident site was located in the commune of Bonvillard (Savoie), at an altitude of 1,800 m and at about 3.2 NM on a radial of 165° with respect to Albertville aerodrome.

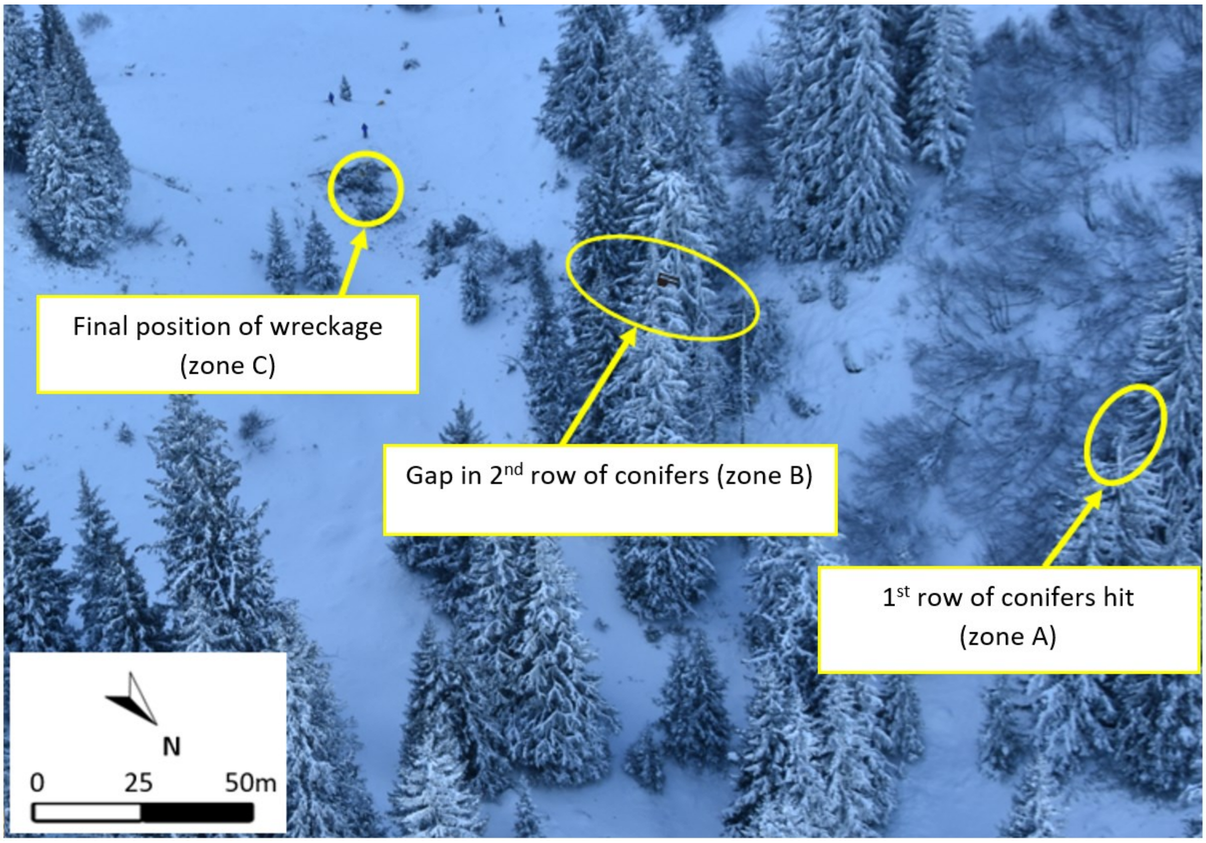

Figure 6: aerial view of site by day on 10 December 2020 (source: GTA)

Three areas of impact could be observed between the helicopter and the vegetation/ground:

- a first impact (Area A) with the top of a first row of conifers;
- a second impact (Area B) in a second row of conifers;
- a final impact with the ground (Area C), corresponding to the final position of the wreckage.

These three areas (A, B and C) were more or less aligned horizontally and vertically. As the field was upward sloping in the direction of the helicopter's final flight path, all these points were at almost the same altitude, which seems to indicate that the helicopter was in level flight on a route roughly oriented on a heading of 165° when it made contact with the vegetation and then the ground.

The wreckage was located in an area of low vegetation, surrounded by several groups of conifers standing at a height of up to around 30 m. To the north-west of the position of the main wreckage and about 50 m from the latter in the direction of the valley, a row of trees was damaged at mid-height. This gap was recent. A large number of branches as well as a lot of debris from the helicopter were found in the gap and on the ground, between this group of trees and the main wreckage.

Figure 7: gap in row of trees (source: BEA)

Another 50 m upstream on the aircraft's path, there was another row of trees. Two of these trees had had their heads lopped off by a few tens of centimetres (Area A).

1.12.2 First visual examination of wreckage at accident site

A first limited examination of the wreckage was carried out at the accident site. The helicopter was destroyed. The wreckage was dispersed. A collection of small debris – mainly foam from the helicopter's main rotor blades and small pieces of windshield/windows – were found on the ground in Area A. Numerous branch pieces of all sizes (up to 15 cm in diameter) were found at the base of the trees in Area B, as well as along the path between Areas B and C.

Figure 8: piece of tree 15 cm in diameter found at site (source: BEA)

Many larger elements of the helicopter were found between the first tree in the row (Area B) and the wreckage (Area C):

- The front right and left doors, the right sliding door and pieces of the tail surface were found at the base of the trees (Area B), as well as elements of the main rotor blades and cabin structure.

Figure 9: snow-covered helicopter debris (source: BEA)

- The front left seat (instructor's position), parts of the right and left landing skids, elements of the hoist, the front section of the fuselage and the fenestron fairing were found between Area B and the main part of the wreckage (Area C).

Figure 10: front left seat (source: BEA)

- The front right seat (pilot's position) was found in the immediate vicinity of the wreckage.

A conifer of about 15 cm in diameter was also uprooted between Areas B and C. All these observations showed that the aircraft suffered substantial damage when it passed through this second row of trees (Area B).

The following elements were also observed on the site:

- The wreckage was lying on its right side. It was perpendicular to the axis of the final path, with the front of the helicopter oriented on a heading of approximately 030°.
- The engines, the Main GearBox (MGB) and the transmission deck were integral.
- The tail boom was fractured and only connected to the airframe by the flexball control cable of the Tail Rotor (T/R).
- The fenestron was damaged, but complete.

The wreckage was recovered in order to carry out more detailed examinations of the helicopter off the accident site.

1.12.3 Recovery of the wreckage

The meteorological conditions were such that the recovery of the large assemblies was only possible in April 2021 and the smaller elements in June 2021.

Figure 11: wreckage cleared of snow before being raised (source: BEA)

Figure 12: raising of wreckage (source: BEA)

The entire wreckage was transported to the BEA's premises to carry out technical examinations.

1.12.4 Examination of airframe and mechanical assemblies

The detailed examination of the airframe found that:

- The airframe of the helicopter was destroyed as a result of the impacts with the vegetation and then the ground.
- The front of the aircraft was totally destroyed as a result of the collisions with the vegetation and then the ground. The side, front and sliding doors as well as the windows had separated from the main airframe.
- The left wall was destroyed. The right wall was damaged, but still integral with the floor and the transmission deck (the wall detached during the recovery).
- The skids were fractured in several places.
- The tail of the aircraft was fractured about mid-distance between the rear of the airframe and the fenestron. This rupture was caused by the impact with the ground.
- All the ruptures observed on the airframe were overload ruptures caused by the impacts with the vegetation and the ground.
- The four main rotor blades showed comparable damage.
- The blade roots were integral with the rotor head, and the damage observed was characteristic of contact during rotation with a relatively soft external element (snow, tree

branches). These observations were consistent with the first two series of rotor impacts with the vegetation.

- The rotor head and the MGB showed signs of impacts, but, overall, were only slightly damaged. The front right MGB attachment had failed due to overload.
- The engine drive shafts were in good condition. They were both disconnected at their splined couplings as a result of the distortion of the airframe on impact with the ground (resulting from a relative movement of the MGB with respect to the two engines). There were limited friction marks on the drive shafts, which seems to indicate that the engines were no longer delivering power on final impact with the ground.
- The tail rotor drive shaft was made up of three short shafts: the forward shaft, the central shaft and the rear shaft. The short forward shaft, made of composite, had failed due to bending as a result of the distortion of the airframe on impact with the ground. The central shaft, made of metal, had failed due to bending as a result of the tail boom separating on impact with the ground.
- The Tail GearBox (TGB) was slightly damaged although rotation was precluded by the distortions of the fenestron blades and fairing.
- The fenestron was composed of 10 blades. One of these blades was bent, two others had impact marks on their trailing edge. This damage occurred with a small amount of residual rotation due to the separation of the tail.
- The fuel tank was fractured in several places. The extent of damage to the helicopter precluded a detailed examination of the fuel system.
- The front section of the airframe was totally destroyed by the final collision with the ground.
- The examination of the flight controls was limited due to the many failures observed, all resulting from overloads.

All of the damage observed on the helicopter was caused by the collisions with the vegetation and the ground. The examinations carried out did not reveal any anomalies or malfunctions that could explain the event.

1.12.5 Summary of engine and cockpit interface examinations

The EC135 T1 is equipped with Arrius 2B1A1 engines, the schematic diagram of which is shown below.

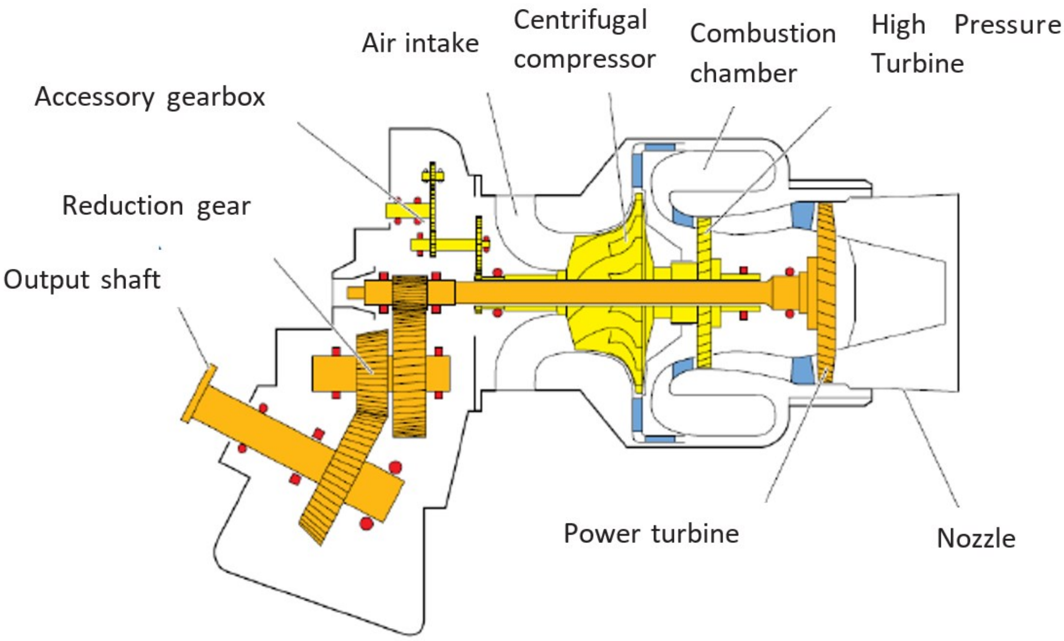

Figure 13: detail of engine components (source: Safran Helicopter Engines, annotated by BEA)

The complete examination of the engine and its accessories is detailed in Appendix 3.

To summarise, the following points were determined:

- One of the two twist grips was found in the "flight" position; the position of the second twist grip could not be determined as it was broken.
- The destruction of the cockpit and the damage to the upper centre console meant that the positions of the different selectors and switches at the time of the accident could not be determined.
- A lot of debris from resinous trees was found in the air intakes of both engines.
- No anomaly was observed on the oil and fuel systems.
- The drive shafts between the two engines and the MGB were coupled on the MGB side but uncoupled on the engine side.
- The coupling splines on the engine side showed shallow, narrow contact marks forming helical tracks, indicating that the drive shaft was rotating when it uncoupled, with reduced power (low torque).
- Signs of surging caused by the ingestion of debris were observed on the air intake of engine 2.
- No other specificities were observed on the engines and their accessories.
- The engines were operating and were producing power at the time of the collision with the vegetation.

1.13 Medical and pathological information

The autopsy carried out on the pilot did not reveal any contributory element to the accident.

1.14 Fire

There was no fire as a result of the impact with the ground.

1.15 Survival aspects

1.15.1 Examination of seats

The front right seat (pilot's seat) was totally destroyed. The four-point harness was found fastened. The extent of damage to the seat did not allow a more detailed examination of the seat or the harness.

The front left seat was damaged. It was found just after the row of trees (Area B). The four-point harness was found fastened. The marks observed on the right shoulder strap appeared to be consistent with a person in the seat with the harness fastened.

Figure 14: shoulder harness of front left seat (source: BEA)

Figure 15: mark on harness right strap of front left seat (source: BEA)

1.15.2 Accident sequence

Initially, the main rotor blades struck the top of conifers (Area A). The helicopter then collided head-on with a group of conifers (Area B). After these two impacts, the helicopter, which was already substantially damaged, collided with the snow-covered ground (Area C).

During the head-on collision with the group of conifers (Area B), the trunk of one of the trees destroyed the cockpit and tore the floor of the cabin, which led to the detachment of the co-pilot's seat on the front left side of the airframe. The instructor pilot, seated in this seat with his four-point harness fastened, was ejected from the helicopter and fell into the snow. At the end of this sequence, although the instructor's harness was fastened at the time of the collision, when he regained consciousness in the snow, he was out of his seat.

The seat harness was found fastened and locked. Incipient cuts were observed in two different places on one of the harness' shoulder straps. This suggests that at the time of the collision with the trees, the shoulder strap lock button was in the "free"[15] position and the pilot's back was probably not pressed against the seat's backrest. The second cut corresponds to a position of the pilot with his back pressed against the seat.

[15] A locking button on the pilot's seat allows the user to switch between the "locked" and "free" positions of the shoulder straps, which allows the pilot to lean forward freely. In this position, however, an automatic (seat belt type) blocking device activates if the forward movement is too sudden.

It is possible that, given this position of the lock button and the collision sequence, the instructor may have slipped out of the seat when the latter separated from the airframe. The thickness of the snow cover in the area of the accident probably cushioned the instructor's fall.

During the collision with the snow-covered ground, the helicopter hit the ground on its front right side, resulting in the destruction of the right pilot's seat. The seat harness was found closed and locked.

Due to the configuration of the helicopter and the type of mission, the other four occupants in the cargo area had only one seat available (on the rear right side), equipped with a lap belt. The occupants who did not use this seat were sitting directly on the floor of the helicopter and had no seat belts. They were all equipped with personal harnesses. Each harness was equipped with a lanyard. This lanyard allowed the two hoist operators to attach themselves to rings connected to the structure of the helicopter, and the two rescuers to attach themselves to the lifeline on the floor.

Note: The lifeline comprises one or more ropes connecting several rings attached to lashing points on the floor or on uprights (strong points) of the structure. The occupants in the cargo area attach themselves to the lifeline by means of the lanyards of their personal harnesses. This secures them when the door is open in flight while giving them freedom of movement in this area. This device is not a substitute[16] for seat belts. However, given the space available and the mission to be carried out, some specific operations[17] may benefit from exceptional or adjusted measures whereby occupants do not have to be secured during specific phases of the flight.

Observations made at the site showed that the occupants in the cargo area were attached to the helicopter using the harness lanyards at the time of the accident. The seat belt of the rear right seat was found unlocked. It was not possible to determine if this seat was being used at the time of the accident.

The successive collisions with the vegetation and then the ground meant the helicopter occupants' chances of survival were slim. Taking into account the structural distortions and the energy on impact, it is unlikely that the presence of individual seats and seat belts in the rear would have increased the chances of survival or reduced the human cost of this accident.

1.15.3 Emergency services organisation

The instructor who was ejected from the helicopter managed to alert the SAF HELICOPTERES operations department by telephone and give the geographical coordinates of the accident site. The company's personnel informed the Savoie CODIS[18] of the accident.

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[16] Level of protection, shock absorption and immobilisation.
[17] Helicopter hoist operations are one of these operations.
[18] Departmental fire and rescue operational centre.

At 17:51, the Lyon ARCC[19], contacted by the Savoie CODIS, raised the alarm and called on the air assets: the CHOUCAS 73 helicopter from the Gendarmery air detachment (DAG[20]) of Modane, and the civil defence's DRAGON 74 helicopter. In coordination with the prefecture, phase C of the SATER[21] plan was triggered. Due to the adverse weather conditions in the accident area, it was not possible for helicopters to fly over the area.

At 18:41, the CHOUCAS 73, limited by a cloud ceiling at an altitude of 1,400 m, set down a team from the PGHM, below the accident area who started climbing towards the accident site.

At 20:48, the team on the ground found the instructor severely injured and hypothermic. The other five occupants were found fatally injured in the vicinity of the helicopter wreckage.

The surviving pilot received medical treatment at the site before being evacuated on foot to the valley by the PGHM rescue team and then transported to Grenoble hospital by road.

At around 01:30 on 9 December, the SAR[22] operation was suspended after the air assets involved had landed and the surviving pilot had been successfully evacuated. The SAR operation was closed at 08:30.

1.16 Tests and research

The helicopter was equipped with several computers to manage and monitor the engines, fuel, electrical power systems, and failures of the onboard systems (see paragraph 1.11).

1.16.1 Computer examination results

1.16.1.1 ECU

The two ECUs recorded the "Collective Pitch Failure", respectively, 54 min 34 s and 54 min and 33 s after the computer was powered on and, respectively, between 0 and 1 min and between 0 and 3 min before the power cut off. There were no other recorded failures for the same flight.

The two recordings of the "Collective Pitch Failure" occurred almost simultaneously during the flight and are indicative of an occurrence common to both engines and very close to the simultaneous power off of both computers.

At this point, both engines were delivering power at an equivalent level and their operating speeds had not reached their limits. Small differences between the parameters of the two engines were recorded. These were due to normal performance variations between engines, normal differences in installation effects between the right and left engines, and a possible slight time difference between the parameter recordings of the two engines.

[19] Aeronautical Rescue Coordination Center.
[20] Gendarmery air detachment.
[21] Air-land rescue.
[22] Search and Rescue.

During the recordings of the “Collective Pitch Failure”, the governor systems of both engines were in a governor mode consistent with flight conditions (automatic governor mode and “Flight” position) and, logically, in a degraded mode resulting from the “Collective Pitch Failure”.

The “Collective Pitch Failure” message appears frequently in accidents at the time when the helicopter suffers an impact. Indeed, the invalid values that cause this failure cannot be reached mechanically due to the design of the lever control linkage. This failure was very probably triggered by the structural distortions resulting from a collision.

1.16.1.2 Brite Saver

The following parameters were retrieved from the computer memory:

Parameter	Unit	Comment
Date/time	hh:mm:ss	Brite Saver time
NG 1 and NG 2	%	Gas generator rpm (engine 1 or 2)
NF 1 and NF 2	%	Free turbine rpm (engine 1 or 2)
NR	%	Main rotor rpm
T4 1 and T4 2	°C	Combustion chamber outlet temperature (engine 1 or 2)
Torque 1 and Torque 2	%	Engine 1 torque and Engine 2 torque
Outside air temperature	°C	-
Oil temperature 1 and Oil temperature 2	°C	Engine 1 oil temperature and Engine 2 oil temperature
Skid contact	Boolean	1 = contact with ground 0 = no contact

When the Brite Saver is not connected to a GNSS system, the date and time are not automatically reset to UTC. The Brite Saver clock was 28 min and 27 s behind the UTC. This value was estimated by synchronising the Brite Saver data with the ECU engine parameters recorded at the time of the “Collective Pitch failure” and with the estimated time of the accident based on the radar data. The last recorded data was at 17:16 (corrected time).

The data pertaining to the last two flights (with crews switching while the engines were running) is plotted in the figure below.

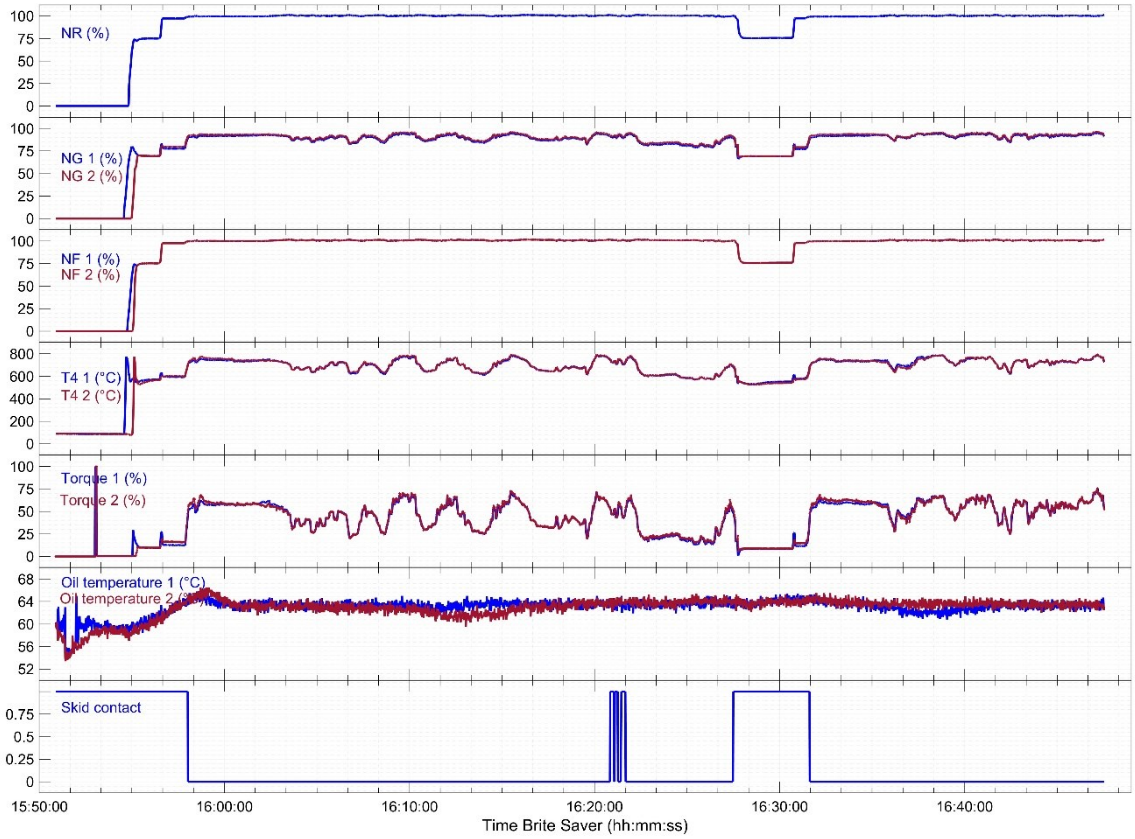

Figure 16: parameters recorded during accident flight and previous flight (source: BEA)

The "skid contact" parameter enabled the two flights to be identified and confirmed the landing at Marret refuge during the first flight. The "NR", "NG", "NF", "T4", "Torque" and "Oil Temp" parameters did not show any engine operating anomaly.

The "NR" and "NF1/2" parameters were correlated. The variations in "NG", "T4" and "Torque" parameters were synchronous and consistent with the different flight phases: take-off, climb, hovering for hoist operations, descent and landing. Nevertheless, the variations (which were less with respect to the hover phases) were more pronounced during the first night flight, which corresponds, for the racetrack patterns, to wider paths and larger turns (smaller bank angle) that require less engine torque.

1.16.2 Flight paths

The flight paths followed during the night flights could be estimated from the DTS information and the radar tracking system[23] which calculates estimated aircraft positions by taking into account information from several radars, as well as by extrapolating past positions.
The radar data was cleaned of obviously erroneous positions.

For the two night flights, the paths were divided into several segments:

1- climb to the hoist operation site;
2- site reconnaissance and path followed for each of the three hoist operations;
3- departure from the site.

[23] In this context, the radar provides at best one position every four seconds. In mountainous areas, detection losses occur due to the terrain forming a screen, which reduces the number of available positions.

During the last daytime flight (flight No 4), a site reconnaissance for the night exercise was carried out with the pilot of the accident flight. Parts of the flight path were retrieved.

1.16.2.1 Climb to hoist operation site

The climb paths to the hoist operation site were reconstructed based on the DTS data (one position per minute).

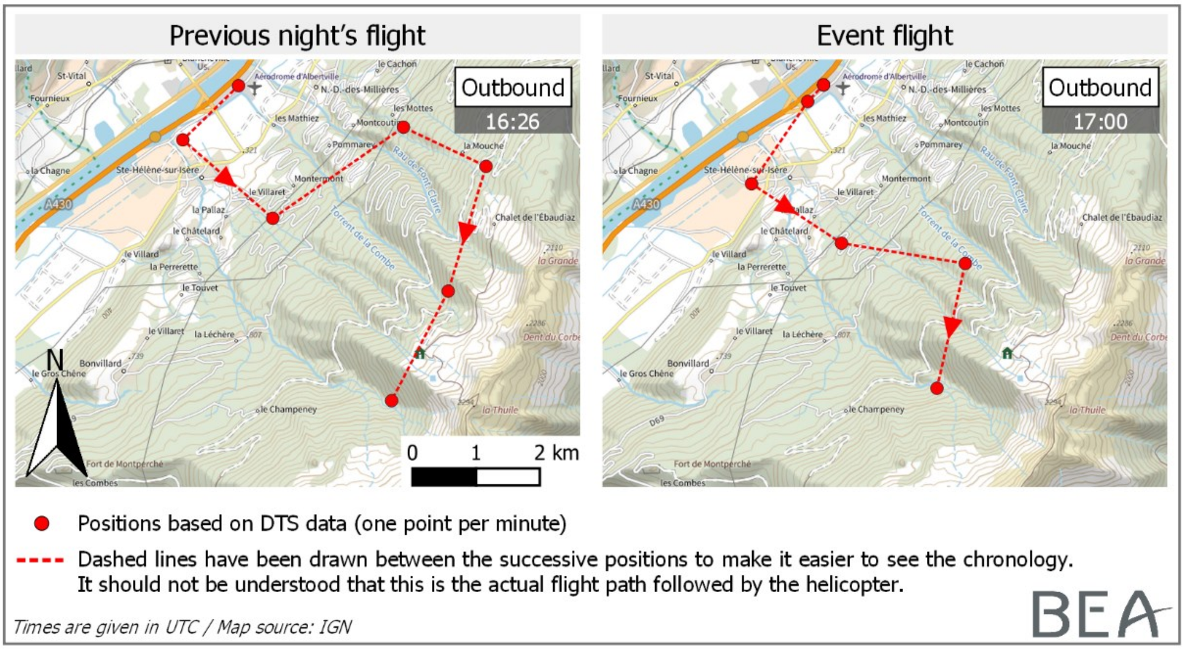

Figure 17: flight path followed to reach exercise site

1.16.2.2 Site reconnaissance and hoist operations

The site reconnaissance flight paths and the manoeuvres for the hoist operations were estimated based on radar tracking data. The recorded positions were plotted at the same scale using the same map dimensions so as to compare the manoeuvre areas during the two night flights. The hoist operation was located at the end of each racetrack pattern.

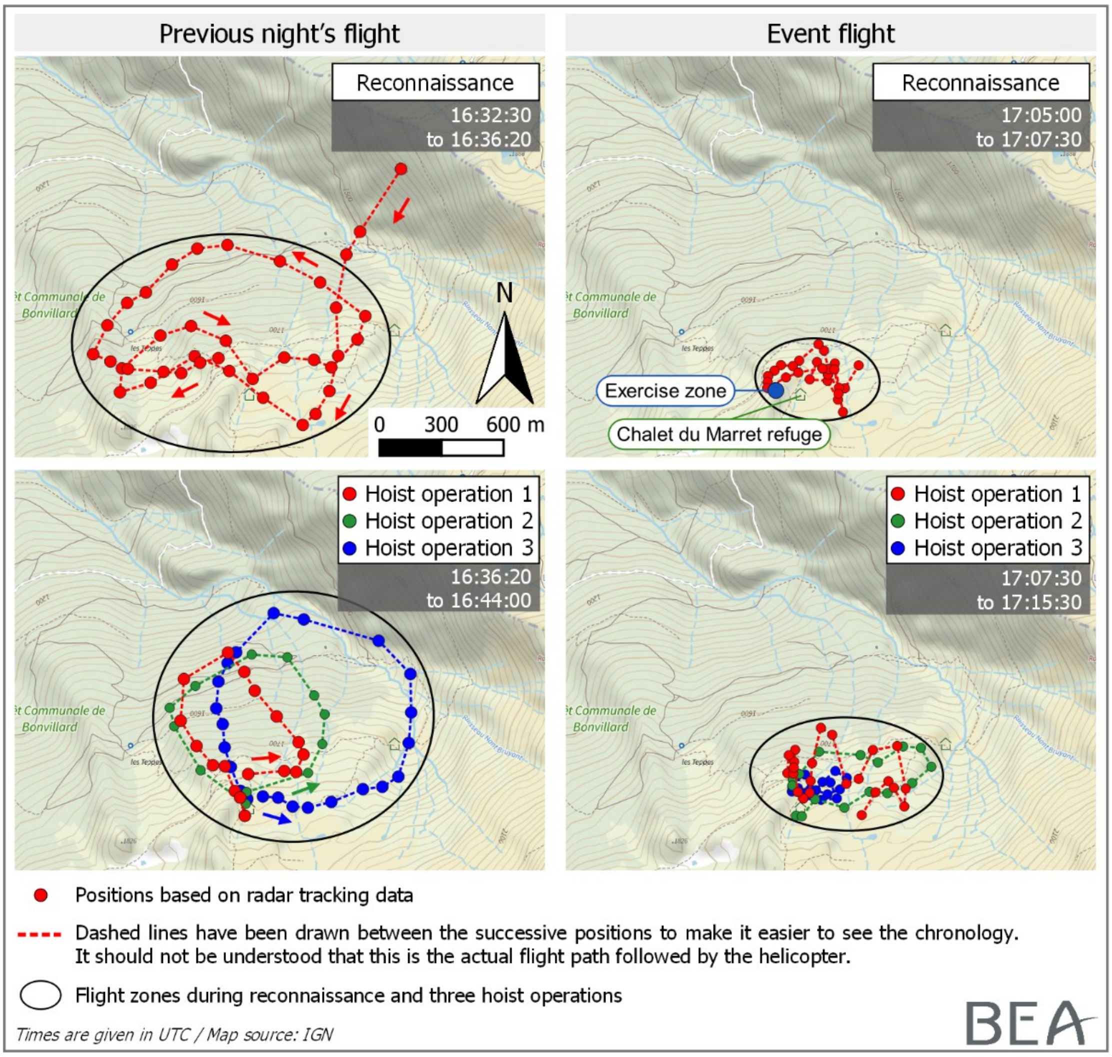

Figure 18: flight paths followed for site reconnaissance and hoist operations

The table below indicates, for the two night flights, the duration of the racetrack patterns, and the time spent hovering over the exercise site, during which the hoist was used for setting down the rescuers or hoisting them back up.

Previous night flight	Duration of the racetrack pattern and hoist operation	Hovering time for the hoist operation
Hoist operation No. 1	2 min and 10 s	Between 40 and 50 s
Hoist operation No. 2	2 min and 15 s	Around 45 s
Hoist operation No. 3	3 min and 15 s	Between 50 and 60 s
Event flight		
Hoist operation No. 1	2 min and 15 s	Around 40 s
Hoist operation No. 2	1 min and 55 s	Around 40 s
Hoist operation No. 3	3 min and 50 s	Between 50 and 60 s

In the previous night flight, a left-hand racetrack pattern had been performed before each hoist operation.

Despite the inaccuracies of the radar positions, it can be seen that during the event flight, a left-hand racetrack pattern was performed before each hoist operation No 1 and No 2.

For hoist operation No 3, two circuits can be seen, the first probably being a left-hand circuit. It was not possible to determine the final approach path for the last hoist operation using the path data.

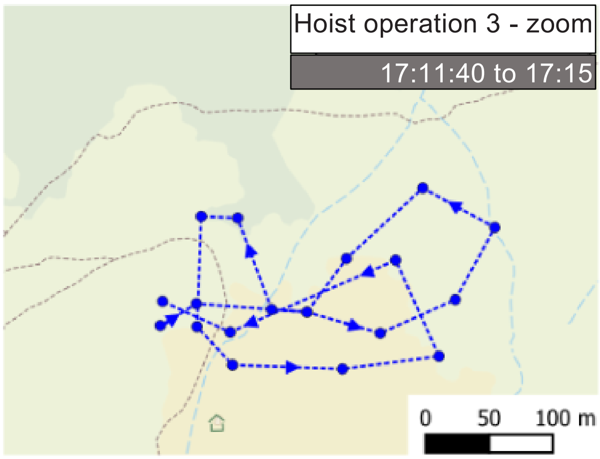

Figure 19: zoom on third hoist operation (source: BEA)

1.16.2.3 Departure from the event flight site

The departure path from the event flight site was estimated based on radar tracking data.

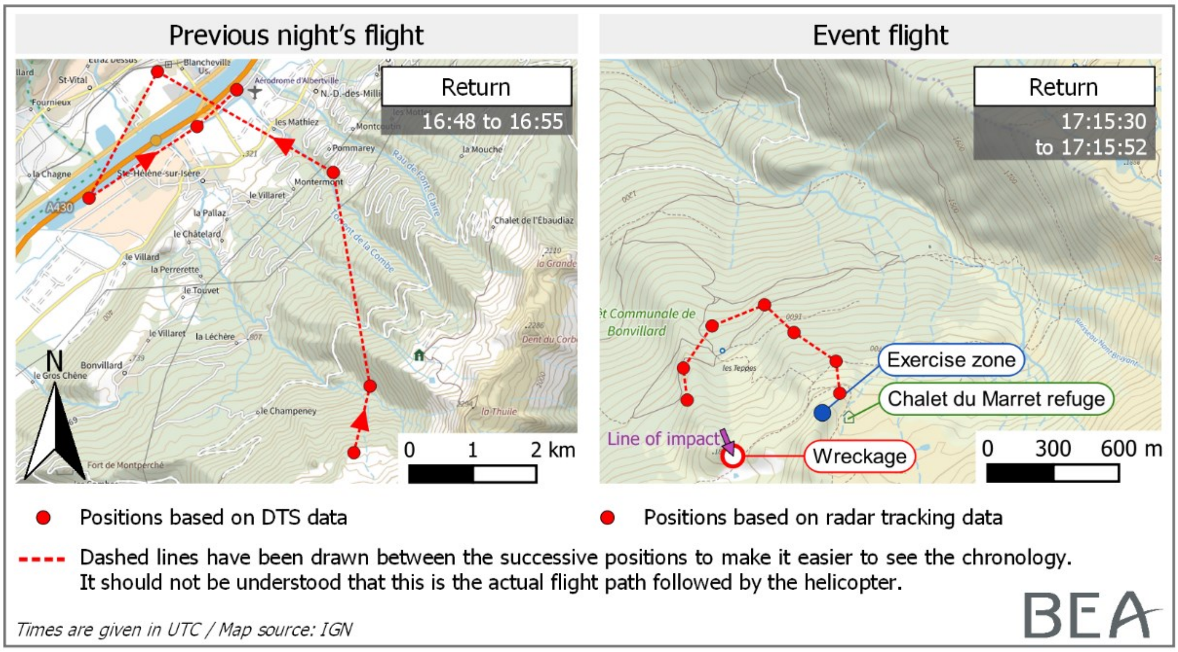

Figure 20: path followed at end of hoist operations

The radar tracking information made it possible to detect a north-westerly flight path when leaving the exercise site[24], with an increase in the helicopter's speed and a left-hand turn at a constant altitude. The estimated end of the flight path was consistent with observations made at the accident site and the position of the wreckage. It is not possible to be precise about the true positions of the helicopter.

1.16.2.4 Daytime flight (No 4)

During this daytime flight (fourth flight), the flight crew was composed of the pilot and the flight instructor of the accident. They looked for a suitable exercise site for the night flights, close to the aerodrome and with sight of the valley. The crew flew over the site for around 2 min 30 s. From overhead the site, the pilot gained speed heading roughly towards Albertville (the town) and then made a slight left-hand turn towards the aerodrome before starting the descent to join the aerodrome circuit.

The flight path for the site reconnaissance was based on the radar tracking data. The return flight path to Albertville aerodrome was reconstructed based on the DTS information recorded by the operator.

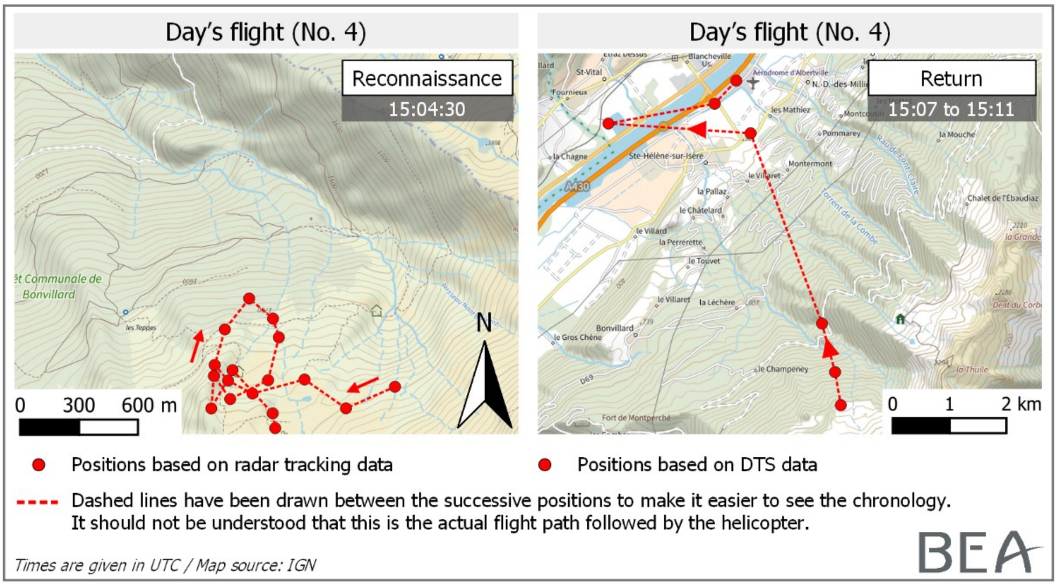

Figure 21: flight path followed during daytime site reconnaissance and return to aerodrome

[24] This data did not allow the initial direction of the helicopter when the pilot flew out of hover to be determined.

1.16.3 Daytime reconnaissance mission by helicopter

A daytime mission by helicopter was organised at the hoist operation site to:

- Assess the visibility conditions of surrounding references depending on the height.
- Follow the flight paths that F-HJAF flew during the hoist operations on the day of the accident and evaluate the environmental constraints according to the helicopter's heading during the hoist operation phases.
- Assess the visibility of Albertville and other villages in the valley by following the final flight path of F-HJAF from the hoist operation site.

The hoist operation site was located on a spur overhanging Marret refuge, about 50 m to the north-west of the latter. The chalet is a visual reference for pilots to position themselves at the hoist operation site with a helicopter oriented in an easterly to southerly direction.

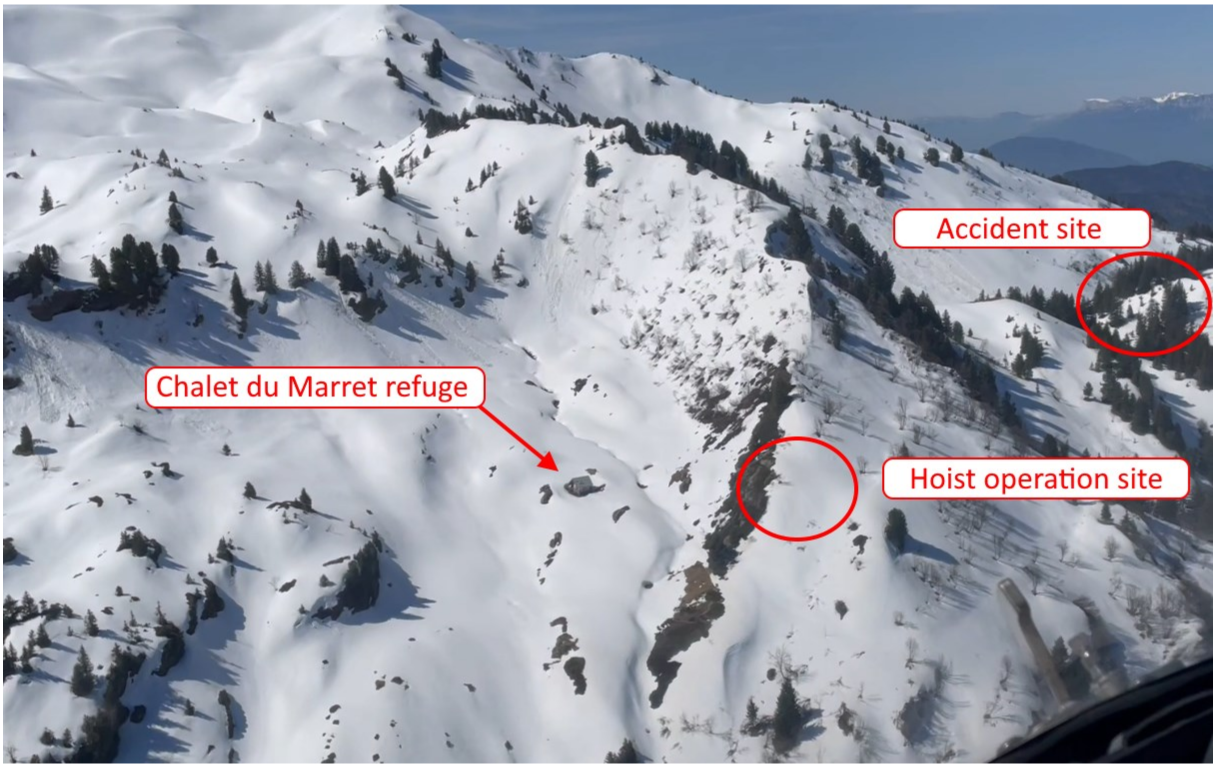

Figure 22: general view of the hoist operation site (facing south-west) (source: BEA)

On reproducing the first night flight, it was found that the north-west/south-east path of the racetrack patterns as well as the visual-reference navigation path avoided obstacles and the surrounding terrain.

Although tighter, the paths followed to reproduce the first two racetrack patterns of the accident flight, in an east-west direction, enabled obstacles and the surrounding terrain to be avoided. However, the final leg to position the helicopter at the hoist operation site was much shorter and required preparatory actions to be anticipated for guidance and hoist operations.

The path followed to reproduce the approach for the third hoist operation (two racetrack patterns) was flown at low speed and took longer than the time calculated for the accident flight. The following points were observed:

- To stay within the same volume as the accident flight, the manoeuvres needed to be tighter than for the first two hoist operations of the same flight.
- The final approach path on the first racetrack pattern of the third hoist operation was short and the preparation time was limited.
- The final approach path on the second racetrack pattern of the third hoist operation was slightly longer and offered a preparation time similar to the first two hoist operations. However, the helicopter was oriented on the spur in the opposite direction to the first two hoist operations.

In order to assess the visibility of Albertville, the helicopter was positioned between the hoist operation site and Marret refuge, pointing towards the town, at an altitude corresponding to that of the hoist operation site, then it gradually rose by 100 m. From the initial position up to 100 m, Albertville was visible; the first (most penalising) ridge line between the hoist operation site and Albertville only masked the south end of the town.

Figure 23: view towards Albertville at altitude of hoist operation site (source: BEA)

On following the accident flight path, from the departure from the hoist operation site at a height of 20 m agl with the helicopter turned towards Marret refuge (south-east), and on turning left to head north-west, it was possible to confirm that:

- Overhead the hoist operation site, Albertville was visible and located on the pilot's left.
- During the turn, the pilot successively had in front of him (direction 12 o'clock): Albertville, Gilly-sur-Isère, Frontenex, and finally Grésy-sur-Isère.
- All the villages in the valley between Albertville and Grésy-sur-Isère were visible.

Figure 24: view from hoist operation site (height 20 m) towards Albertville during left turn (source: BEA)

1.16.4 Drone mission

On 25 August 2022, the BEA had videos and photos taken by drone overhead the exercise site (at heights of 20 m, 30 m and 50 m), at sunset, at the beginning of the aeronautical night (sunset + 30 min), at night (moonless night at sunset + 2 h) in order to assess the visibility of the town lights situated in the valley.

The following three photos taken in the direction of Albertville, the aerodrome and Grésy-sur-Isère, two hours after sunset, show the town lights situated in the valley and visible overhead the exercise site at a height of 50 m.

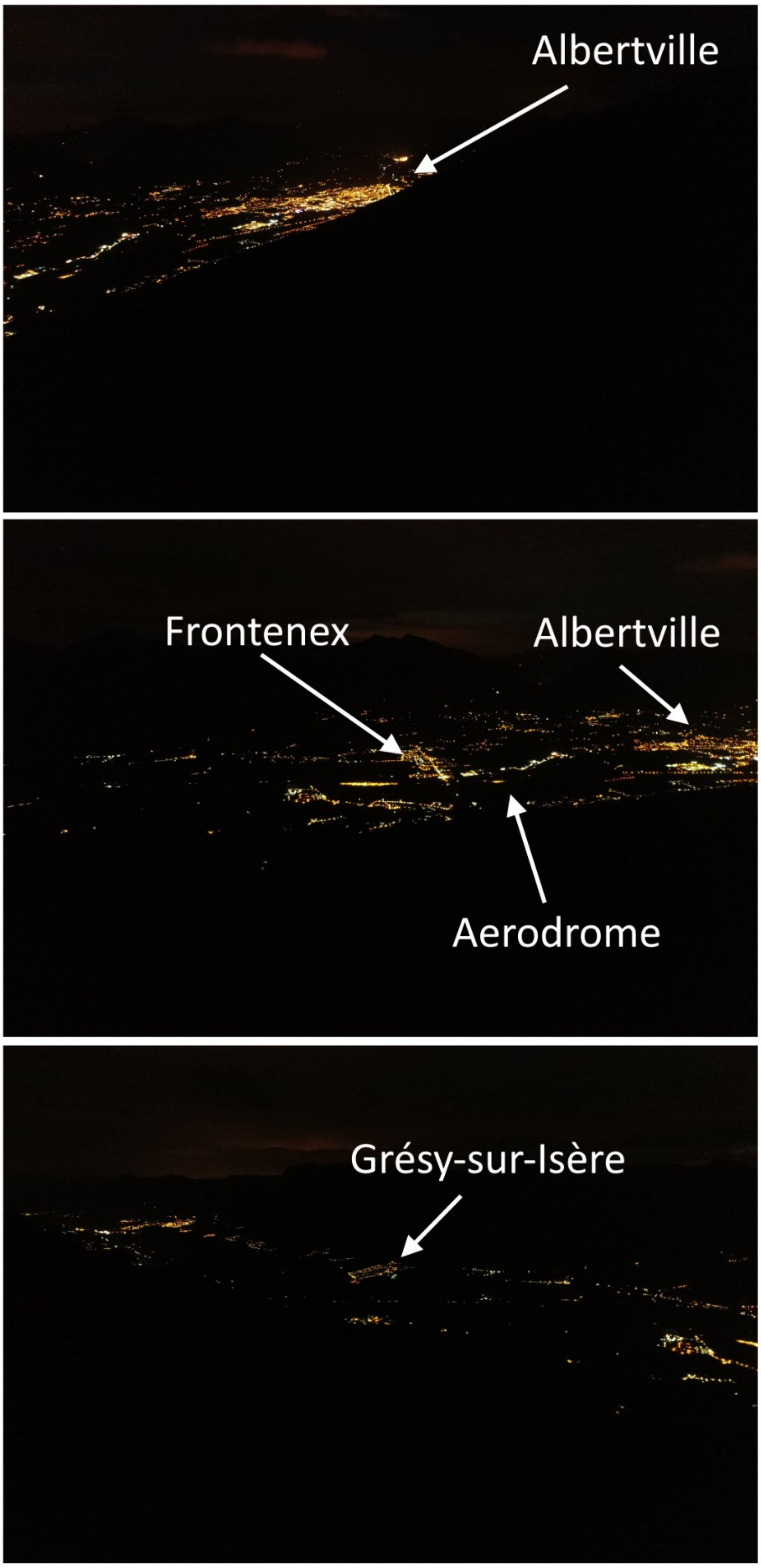

Figure 25: night photos (source: BEA)

BEA

1.17 Organisational and management information

1.17.1 Regulatory scope and applicable regulations

1.17.1.1 Regulatory scope for mountain rescue operations

In France, up to 2019, commercial helicopter companies involved in day and night mountain rescue missions applied the amended Order of 24 July 1991 relating to the conditions of use of civil aircraft in general aviation.

In 2019, in order to clarify the regulatory scope applicable to mountain rescue missions, the DSAC published a guide[25] for helicopter operators which, among other things, makes a distinction between the following:

- emergency **non-medical** operations, for which the national frame of reference applies, with the Order of 24 July 1991 and
- emergency **medical** evacuation, for which "AIR.OPS" regulation applies.

Moreover, HEMS[26] flights must comply, in particular, with the provisions of:

- the CAT part of the AIR.OPS regulation;
- the specific SPA.HEMS approval of the same regulation.

In order to cover all configurations of mountain rescue responses subject to the HEMS scope, helicopter hoist operations that may be required during mountain rescue missions are subject to the regulatory requirements of the SPA.HHO specific approval of the AIR.OPS.

The NPA[27] 2018-04 to amend the AIR.OPS, proposed by EASA in 2018, aimed to modify the regulations for HEMS flights and extend their scope to take into account the full mountain rescue activity, whether medical evacuation is included or not. This proposed amendment to the regulations was scheduled to come into force in 2020, but had not yet been implemented at the time of the accident.

1.17.1.2 Part SPA.HHO of consolidated Regulation (EU) No 965/2012

Annex V (PART-SPA) of the AIR.OPS regulation[28] contains the regulatory requirements for the SPA.HHO (Helicopter Hoist Operations) approval.

Three requirements of this regulation especially deal with:

- The administrative conditions for carrying out helicopter hoist operations (requirement SPA.HHO.100).
- The experience requirements applicable to crews, in particular the delegation that is granted to the operator to define a training programme approved by the national authority (requirement SPA.HHO.130).

[25] Secours en montagne par hélicoptère : cadre règlementaire applicable (Mountain rescue missions by helicopter: applicable regulatory scope (available in French only)) (see media library).

[26] Helicopter Emergency Medical Services.

[27] Notices of proposed amendment.

[28] Version in force on the day of the accident.

- The requirements concerning the need to ensure risk analysis and management for this activity, as well as the operational and organisational constraints to minimise the associated risks (requirement SPA.HHO.140).

"SPA.HHO.100 Helicopter hoist operations (HHO)

a) Helicopters shall only be operated for the purpose of CAT hoist operations if the operator has been approved by the competent authority.

b) To obtain such approval by the competent authority, the operator shall:

1) operate in CAT and hold a CAT AOC in accordance with Annex III (Part-ORO);

2) demonstrate to the competent authority compliance with the requirements contained in this Subpart."

"SPA.HHO.130 Crew requirements for HHO

a) Selection. The operator shall establish criteria for the selection of flight crew members for the HHO task, taking previous experience into account.

b) Experience. The minimum experience level for the commander conducting HHO flights shall not be less than: […]

Onshore:

i. 500 hours as pilot-in-command/commander of helicopters, or 500 hours as co-pilot in HHO of which 100 hours is as pilot-in-command under supervision;

ii. 200 hours operating experience in helicopters gained in an operational environment similar to the intended operation; and

iii. 50 hoist cycles, of which 20 cycles shall be at night if night operations are being conducted.

c) Operational training and experience. Successful completion of training in accordance with the HHO procedures contained in the operations manual and relevant experience in the role and environment under which HHO are conducted.

d) Recency. All pilots and HHO crew members conducting HHO shall have completed in the last 90 days:

1) when operating by day: any combination of three day or night hoist cycles, each of which shall include a transition to and from the hover;

2) when operating by night: three night hoist cycles, each of which shall include a transition to and from the hover.

e) Crew composition. The minimum crew for day or night operations shall be as stated in the operations manual. The minimum crew will be dependent on the type of helicopter, the weather conditions, the type of task […]. In no case shall the minimum crew be less than one pilot and one HHO crew member.

f) Training and checking

1) Training and checking shall be conducted in accordance with a detailed syllabus approved by the competent authority and included in the operations manual.

2) Crew members

i. Crew training programmes shall: improve knowledge of the HHO working environment and equipment; improve crew coordination; and include measures to minimise the risks associated with HHO normal and emergency procedures and static discharge.

ii. *The measures referred to in (f)(2)(i) shall be assessed during visual meteorological conditions (VMC) day proficiency checks, or VMC night proficiency checks when night HHO are undertaken by the operator."*

"SPA.HHO.140 Information and documentation

a) The operator shall ensure that, as part of its risk analysis and management process, risks associated with the HHO environment are minimised by specifying in the operations manual: selection, composition and training of crews; levels of equipment and dispatch criteria; and operating procedures and minima, such that normal and likely abnormal operations are described and adequately mitigated.

b) Relevant extracts from the operations manual shall be available to the organisation for which the HHO is being provided."

1.17.2 General organisation of SAF HELICOPTERES and missions

1.17.2.1 General

SAF HELICOPTERES has:

- An OM containing all the applicable procedures and instructions to carry out its commercial air transport operations (known as "CAT") and specialised operations (known as "SPO").
- An Air Operator Certificate (AOC) referenced FR.AOC.0037 allowing it to perform commercial air transport flights.
- A Specific activities manual in order to carry out its operations within the scope of the Order of 24 July 1991[29], and a training manual for the specific activities described in the Specific activities manual.

1.17.2.2 Missions and fleet

SAF HELICOPTERES carries out the following operations:

- Commercial air transport flights covered by the provisions of Part-CAT of the AIR.OPS regulation.
- Aerial work flights covered by the provisions of Part-SPO of the same regulation.
- Day and night HEMS flights covered by the provisions of Part-CAT and the specific approval of Part-SPA.HEMS.
- Mountain rescue flights covered either by the provisions of Part-CAT and the SPA.HHO and SPA.HEMS specific approvals of the AIR.OPS, or the Order of 24 July 1991.

In addition, SAF HELICOPTERES holds the AIR.OPS SPA.NVIS[30] specific approval. SAF HELICOPTERES informed the BEA that only the Besançon base had flown flights using Night Vision Goggles (NVG).

The company's fleet was composed of AIRBUS AS350, EC130 and EC135 helicopters.

[29] https://www.legifrance.gouv.fr/loda/id/JORFTEXT000000537341/2020-03-05

[30] Operations with Night Vision Imaging Systems.

1.17.2.3 Organisation

In accordance with the AIR.OPS regulations, the organisation of the company is structured around the following areas of responsibility:

- Management: Accountable Manager
- Safety: Safety Manager
- Compliance: Compliance Monitoring Manager (CMM)
- Flight Operations: Nominated Person for Flight Operations (NPFO) and two deputies (pilots)
- Ground Operations: Nominated Person for Ground Operations (NPGO)
- Training: Nominated Person for Crew Training (NPCT) and one deputy
- Airworthiness: Nominated Person for Continuing Airworthiness (NPCA)

The role of the NPCT is defined in Part A of the OM:

- **Responsibilities:**

The Nominated Person for Crew Training ensures that the proficiency level and validity of crew ratings are maintained to ensure the safety of SAF HELICOPTERES operations.

- **Main tasks:**

For the flight crews, the NPCT must:

- Acquaint him/herself with the monthly regulatory monitoring report issued by the CMM and modify the training and exercise programmes, if necessary.
- Develop and monitor initial and continuous training programmes.
- Develop and/or supervise the production of training materials.
- Draft and amend Part D of the Operations Manual.
- Set up and update individual training records.
- Monitor the validity of recent experience, documents, training courses, exercises and recurrent checks.
- Plan training sessions, flight tests, exercise sessions and recurrent checks.
- Nominate the company's SPO supervisors and instructors.
- Supervise instructors, supervisors and examiners.
- Ensure that the pilots' practice level is sufficient for the missions to be performed.
- Carry out flight and ground proficiency tests when recruiting pilots.
- Deliver certain courses during pilot meetings.
- He/she shall ensure that recurrent training sessions, flight checks and other training activities are planned as early as possible.
- He/she shall ensure that Air Maestro's "yellow"[31] alerts are taken into account and that training actions are planned.

[31] Alert indicating that the risk identified on a mission requires verification.

The role of the NPFO is defined in Part A of the OM:

- **Responsibilities:**
  - He/she ensures that the defined operating procedures comply with the regulations in force and the company's safety standards, and modifies them if necessary.
  - He/she is responsible for verifying the correct implementation of operating procedures by the company's flight crew.
  - The NPFO is responsible for choosing the crews and helicopters for the company's flights. However, he/she may delegate the above-mentioned choices to qualified personnel. When crews are chosen using Air Maestro, any person with access to the planning module can select a crew under the authority of the NPFO. In the event of a non-conformity, the NPFO will receive an alert 20 h before the mission starts.
  - The NPFO can rely on the skills of the company's pilots.

- **Main tasks:**

The NPFO must:

  - Acquaint him/herself with the monthly regulatory watch report issued by the CMM and modify the flight operating procedures, if necessary.
  - Draft Parts A, B and C of the OM as well as specific manuals or procedures in relation to particular missions (SOSM, PSP, etc.).
  - Choose crews taking into account the specificities of each mission.
  - Supervise and check that flight crews comply with operating procedures.
  - Check and control flight records and ensure they are filed.
  - Ensure technical preparation of special missions with the applicable nominated persons.
  - Deliver certain courses during pilot meetings.

1.17.2.4 Operations Manual (OM)

In accordance with the AIR.OPS, the OM is divided into four parts:

- Part A (A.CAT and A.SPO): covers the general information, the company's organisation, the operating procedures and the applicable policy within the company.
- Part B: contains, for each aircraft in the company's listed fleet, all of the topics related to the operation of the aircraft depending on its type and version.
- Part C: contains all the instructions and information regarding routes, helicopter landing surfaces and areas used as part of CAT operations.
- Part D (D.CAT and D.SPO): includes all the personnel training programmes associated with the company's commercial air transport (D.CAT) and aerial work (D.SPO) operations. Special operations such as SPA.HEMS and SPA.HHO are included in part D.CAT.

The OM was amended in October 2020 to take into account the SPA.HHO specific approval in order to perform helicopter hoist operations, including emergency medical evacuation missions. A supplement to the OM dealing with SPA.HHO operating procedures was also added (see paragraph 1.17.3.2).

The company was authorised to perform night VFR flights as part of:

- Commercial air transport to carry passengers or cargo.
- Operations requiring a special authorisation: SPA.HEMS, SPA.HHO, SPA.NVIS.
- General aviation (ferry, return from mission, night flight training, Line Check (LC) and Operator Proficiency Check (OPC) flights, non-medical mountain rescue missions, etc.).

1.17.2.5 Specific activities manual and Training manual for specific activities

The Specific activities manual[32], in force at the time of the accident in accordance with the Order of 24 July 1991, included helicopter hoist operations. In the case of operations not subject to the AIR.OPS regulation (excluding OM), the Specific activities manual was applicable. The Specific activities manual described, among other things, the organisation of operations within the company, the operating conditions, the crew experience and rating requirements and prerequisites, as well as the operations involved.

For helicopter hoist operations (section 6 of the Specific activities manual), contrary to other operations, the Specific activities manual did not specify whether these operations could be performed during the day or at night. However, it did set out rating and experience requirements. The Specific activities manual also dealt with rescue procedures, the different hoists that could be used, the essential equipment, the preparation and performance of operations as well as the prerogatives of the pilots-in-command to decide whether to continue, abort or cancel the mission if they estimate that safety is compromised.

The Training manual for specific activities is associated with the Specific activities manual and describes the skills that need to be taught in order to award the ratings required to perform these specific operations.

1.17.3 SPA.HHO approval

1.17.3.1 History and ratification of the approval

SAF HELICOPTERES had been operating helicopters equipped with hoists for many years, in particular as part of daytime mountain rescue operations in the winter season, in accordance with the Order of 24 July 1991.

SAF HELICOPTERES applied for SPA.HHO approval in addition to the SPA.HEMS approval already obtained in order to perpetuate these mountain rescue operations, in anticipation of changes in European regulations and to comply with the guide published by the DSAC (see paragraph 1.17.1.1). This request for approval allowed SAF HELICOPTERES to continue its helicopter hoist operations for daytime mountain medical evacuation missions and extend them to night operations. This request included a specific training programme. The purpose of this training was to provide pilots and hoist operators with the necessary know-how to perform helicopter hoist operations as part of a normal flight crew complement in accordance with the regulatory requirements of part SPA.HHO of the AIR.OPS regulation.

SAF HELICOPTERES specified to the BEA during the investigation that the operational objective was to be able to finish mountain rescue operations started at the end of the day, after nightfall. There were no plans to initiate helicopter hoist operations at night.

[32] Issue 5 Revision 7 dated 14 October 2016.

The request for SPA.HHO approval and the training programmes (pilot and TCM) submitted by SAF HELICOPTERES on 13 October 2020 was approved by the DSAC-CE on 4 December 2020, four days before the accident.

1.17.3.2 SPA.HHO supplement to the SAF HELICOPTERES OM

SAF HELICOPTERES drew up a specific supplement to the OM which describes all the procedures applicable to helicopter hoist operations as part of commercial air transport flights (SPA.HHO), in particular helicopter emergency medical service operations (SPA.HEMS). It is specified that the supplement will also be used as support material for the initial and recurrent training of crew members.

The aim of the document is to ensure flight safety by guaranteeing that the crews have good knowledge of the EC135 hoist and operate it correctly. The preamble specifies that exceptionally, crew members may have to adapt the standard procedure depending on the situation encountered. This 72-page supplement describes:

- The hoist and associated systems and/or components.
- The limitations of the EC135 equipped with the hoist and the hoist limitations.
- The applicable standard procedures.
- The emergency procedures.
- The equipment for the on-board and response personnel and for the helicopter.
- The weight and balance limitations (lateral and longitudinal centre of gravity) specific to these operations.
- The technical preparation of the hoist and specific checks during the before flight inspection.

In all of the document, the specificity of night hoist operations is addressed in a one-page paragraph in the standard procedures. A note therein indicates that during the take-off phase, it seems appropriate to ask the pilot to climb vertically in order to be able to fly forward more quickly (reduced visibility outside the search light) and the paragraph, Advice to pilots specifies that the controls must be used with a smooth, precise touch as it is not always easy for the pilot to detect the references (limited to the light beam or external lighting). The specific risks associated with night in a mountainous environment where SAF HELICOPTERES operations may take place (e.g. loss of external references in the mountains or loss of sight of the hoist operation area) are not dealt with in this document.

1.17.3.3 Risk assessment and management of SPA.HHO operations

In order to integrate the SPA.HHO into the company's operations and obtain the approval from the DSAC-CE, SAF HELICOPTERES had to carry out a "change assessment" and a "safety impact assessment". These two assessments were combined in a single document.

The change assessment listed the documents and procedures that were modified. It was based on a compliance matrix which described in detail, the additions to the OM to meet the regulatory requirements.

The operational use of crews holding the "Advanced HHO" rating defined by SAF HELICOPTERES in Part D of the OM (para. D.2.1.5.2.D) is as follows:

- Pilots holding the "Advanced HHO" rating can carry out any type of HEMS missions using the hoist in a mountainous area and/or at sea, as well as at night, as long as they have completed the corresponding advanced training. SAF HELICOPTERES considers that this training supplements the pilot's training and experience in the environment in question (see AIR OPS-Annex V-SPA.HHO.130).

The operational and meteorological minima for SPA.HHO operations are identical to those for SPA.HEMS as defined in Part A of the OM (paragraphs A.8.6.6.8 and A.8.2.4.2). These minima apply to:

- daytime operations with a ceiling at 1,200 ft and visibility of 3 km;
- night-time operations with a ceiling at 1,500 ft and visibility of 5 km.

Aerological conditions are also taken into account in the OM:

- If the aerological conditions are disturbed, then hoist operations are prohibited. The pilot-in-command will decide whether to accept or refuse the mission based on the conditions at the time, and on a prior aerological reconnaissance.

The conditions pertaining to flight experience in the area and environment are also described in Part A of the OM (paragraphs A.8.6.6.5 and A.5.1.4.3):

- Before being able to carry out SPA.HHO operations, a pilot-in-command shall prove at least eight months of operations in the geographical environment (mountain - sea - plain area). This experience may include any equivalent experience within the armed forces, Gendarmery and/or Civil Defence and/or with any civilian operator.

The safety impact assessment was based on a risk map (see Appendix 9: Map of risks associated with SPA.HHO operations) which identified the potential hazards associated with SPA.HHO operations and the preventive barriers to reduce the probability of occurrence and/or the severity associated with the undesirable event.

The risk map proposed in the form of a table focused mainly on the hoist operation itself, excluding the flight phases to reach or leave the mission site. Ten hazards (from 1 to 10) were identified. The preventive barriers were briefly addressed, but no document describing precisely the risk mitigation study and the references to parts of the OM dealing with this were proposed in an appendix to the map table.

Only one hazard (No 8) could concern both the hoist operation and the flight phase to reach or leave the mission site, without this being explicitly expressed.

- No 8: Safety distance too small between the aircraft and the obstacles. The preventive barrier focuses on mission preparation (area reconnaissance), training and crew experience.

No specific hazards related to very low level flight in mountainous areas, night flight (in plain or mountainous areas), night flight in light or dark conditions, aerological conditions or loss of visual reference (day or night) were taken into account in this risk map.

1.17.4 SPA.HHO training plan

The training plan described in detail the selection process and supplementary training of *primo* instructors delivering pilot and TCM training. The selection process for these *primo* instructors was based on the recognition of their skills in hoist operations, combined with supplementary ground training and flight practice. As such, the NPCT (as pilot) and the NPFO (as hoist operator) were nominated as the *primo* instructors for this SPA.HHO training.

The training plan specified that the SPA.HHO training programme for *ab initio* staff was broken down into two levels: “Initial” and “Advanced”. These were described in the OM Part D (see paragraph 1.17.5 for pilots and Appendix 8: SPA.HHO (Part TCM) training for TCMs).

The SPA.HHO “Initial” training plan also gave in detail the policy applied by SAF HELICOPTERES to train pilots and TCMs who had hoist operation experience and already held HEC 1 and HEC 2 (Human External Cargo) ratings on the EC135 and the AS350 as part of SPO aerial work operations.

It was specified that the programme described in the OM would be adjusted by the NPCT to take into account the experience already acquired by pilots and TCMs in hoist operations. These personnel would complete a tailored theoretical programme which would nevertheless include all the modules. In terms of the practical aspects, the programme would focus on standardisation of normal and emergency procedures, as well as on communication and coordination within the crew. This action would again include all the aspects addressed in the submitted programme. No tailoring of the “Advanced” training programme was planned.

According to SAF HELICOPTERES, the pilots and hoist operators selected for the first training programmes had substantial helicopter hoist operation experience by day and in particular, in mountainous regions. This training was to standardize the crew work methods. Consequently, the NPCT and NPFO simplified the planned training, particularly for daytime flights.

1.17.5 SPA.HHO training (pilot part) described in OM

1.17.5.1 Personnel qualified to deliver pilot training

In section 1.8.3 of the OM part D for HHO training, SAF HELICOPTERES defined the personnel who are qualified to provide this training: pilot designated by the NPCT-FI [Flight Instructor]/TRI [Type Rating Instructor] with flight experience > 500 hoist operations.

1.17.5.2 Levels and selection criteria

The training at SAF HELICOPTERES was broken down into two levels of HHO operations.

“Initial HHO” approval
A pilot holding the “Initial HHO” approval is able to perform hoist operations in plain areas, where reliable visual references are in close proximity and where obstacles or specific terrain shapes prohibit landing.

Prerequisites
The pilot-in-command must have a minimum experience of 500 flight hours as pilot/pilot-in-command before undertaking this training. Subsequently, in order to take part in real missions as a pilot-in-command, a minimum experience of 50 hoist operations is required.

Recognition of experience
For pilots who already have proven experience in helicopter hoist operations acquired within SAF HELICOPTERES, the armed forces or another company, an assessment shall be carried out by the NPCT or a nominated experienced pilot.

Following this assessment and according to the criteria specified below, the NPCT may reduce training to the acquisition of information about the procedures applied by SAF and the equipment they will be using. As a minimum, theoretical module No 6, a "HHO procedures" flight and an "emergency procedures" flight shall be performed.

Criteria for delivering reduced training:

- Assessment level.
- Total experience in hoist operations.
- Experience with equipment similar to that operated.
- Geographical environment in which the applicants acquired their hoist operation experience (example: France, Canada, Africa, etc.).
- Recent experience of the applicant.
- The applicant must have carried out a minimum of 50 hoist operations, (all types of experience); and/or they must have carried out 50 hoist operations by the end of the reduced training course.
- Experience on the type of aircraft operated.

Content of the assessment

This includes the HHO theoretical training final test, as well as some items of the HHO practical training final test (see Check Forms).
After these two tests, the NPCT shall tailor the training to fully prepare the applicant for the HHO training final test (see Check Forms).

"Advanced HHO" approval

Pilots holding the "Advanced HHO" rating can carry out any type of HEMS missions using the hoist in a mountainous area and/or at sea, as well as at night, as long as they have completed the corresponding advanced training. SAF HELICOPTERES considers that this training supplements the pilot's training and experience in the environment in question (see AIR OPS-Annex V-SPA.HHO.130).

Prerequisites and recognition of experience

The criteria required to be eligible for the "Advanced HHO" approval are as follows:

- Pilots must have carried out a minimum of 50 hoist operations.
- The NPCT must take into account the applicant's total experience according to the following criteria:
  - HEMS operations using a hoist;
  - HHO operations on the type of aircraft;
  - total experience of the applicants in relation to their previous HHO operations;
  - geographical environment in which the applicants acquired their flying experience.

1.17.5.3 Training programme

Ground training consists of six modules for a total duration of 12 h and 30 min and a 30-min theoretical test.

Flight training for the "Initial HHO" approval (see Appendix 5: SPA.HHO "Initial") involves three flight sessions, each lasting one hour and comprising six hoist operations. This training is followed by a check flight lasting 40 min.

Instructor training sheets supplement the submitted SPA.HHO training programme and provide the instructor with details regarding the content of each flight session. These sheets aim to:

- enable instructors to deliver standardised instruction following a defined scenario;
- fix teaching methods while ensuring optimum safety.

Depending on the helicopter's type of operation, flight training for the "Advanced HHO" approval (see Appendix 6: SPA.HHO "Advanced mountain" and "Advanced night") involves:

- For HHO operations in mountainous areas: three flight sessions, each lasting one hour and comprising six hoist operations.
- For night-time HHO operations: two flight sessions, each lasting one hour and comprising six hoist operations.

The training programme as submitted by SAF HELICOPTERES and approved by the DSAC did not provide for any tailoring of the programme for the "Advanced HHO" approval and did not provide for the simultaneous performance of initial and advanced training courses as part of the same session.

A comparable description of the selection criteria and training programme was defined in the OM for hoist operators (See Appendix 8: SPA.HHO training (Part TCM)).

1.17.6 SPA.HHO training delivered/scheduled for Monday 7 to Wednesday 9 December

1.17.6.1 Programme

The SPA.HHO training approval was issued by the DSAC-CE on Friday 4 December 2020. The crews concerned by this training received by email, the same day, the theoretical and practical training programme (see Figure 26).

The training programme that the trainees were to follow and that was sent to them did not describe in detail the ultimate objectives of this training. It was not possible to know whether this training programme, in the event of a successful check flight, was to obtain the SPA.HHO "Initial" approval, or SPA.HHO "Initial" and "Advanced Mountain" approvals, or SPA.HHO "Initial" and "Advanced Mountain" and "Advanced Night" approvals.

For each of the daytime flights, given the presence of two people in training (a pilot and a hoist operator), the NPCT had established the following rule: during each exercise, the pilot in instruction would be associated with the instructor hoist operator, and the hoist operator in training would be associated with the instructor pilot. In this way, for each of the flights performed according to this rule, the number of hoist operations carried out was split between the two trainees.

For the night flights, the two trainees (pilot and hoist operator) would work together under the supervision of the instructor pilot and the instructor hoist operator. In this way, the two trainees benefited from the full duration of the flight and the total number of hoist operations carried out.

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Une action de formation SPA.HHO est planifiée du 7 au 9 décembre au profit d'équipages de SAF Hélicoptères. Celle-ci consiste en une phase théorique et une phase pratique conformément au programme déposé.

1- **_Personnels présents :_**

a. ***Instructeurs :*** Instructeur pilote RDFE, Instructeur treuilliste RDOV
b. ***Pilotes :*** 4 pilotes en formation
c. ***Treuillistes :*** 2 treuillistes en formation

2- **_Planification :_**

	Lundi 07/12	Mardi 08/12	Mercredi 09/12
8h00-9h00	Formation théorique (tous)	**Vol 1 :** Evaluation Pilote n°1, Treuilliste n°1	Briefing Vol de contrôle.
9h30-10h30		**Vol 1** : Evaluation Pilote n°2, Treuilliste n°2	**Vol 4** : Contrôle Pilote n°1, Treuilliste n°2
11h00-12h00		Débreifing vpl 1 / Briefing vol 2	**Vol 4 :** Contrôle Pilote n°2, Treuilliste n°1
12h00-13h00		Déjeuner	Déjeuner
13h00- 14h30		**Vol 2 :** Procédures norm/Sec Pilote n°1, Treuilliste n°1	Débriefing/Modalités administratives
15h00-16h30		**Vol 2 :** Procédures norm/Sec Pilote n°2, Treuilliste n°2	
16h30-17h30		Débreifing vpl 2 / Briefing vol 3	
17h30-19h00	Briefing « Evaluation »	**Vol 3** : VDN Pilote n°1, Treuilliste n°1 Pilote n°2, Treuilliste n°2	

Figure 26: flight programme submitted for SPA.HHO training (source: SAF HELICOPTERES)

1.17.6.2 Pilot and hoist operator training logs

The training logs of the two pilots and the two hoist operators found after the accident had been opened and contained personal and aeronautical experience information. The decision to adjust the flight training programme had not been recorded. The theoretical training followed, the result of the test for this training, as well as the result of the assessment flight which was supposed to validate the decision to reduce the programme, had not been recorded on the sheet.

1.17.7 Summary of ratings and prerequisites to perform the flights

For the day and night flights, the analysis of the documents showed the following:

- The instructor held a valid instructor rating, he had completed the SPA.HHO (Pilot) *primo* instructor course and held the type rating on this helicopter along with the night rating. He also had the required experience in flight hours and hoist operations to provide SPA.HHO (Pilot) training by day and by night (in accordance with the regulations in force and the SAF HELICOPTERES OM).
- The hoist instructor had completed the SPA.HHO (TCM) *primo* instructor course and had the required level of experience to deliver SPA.HHO (TCM) training by day and by night.
- The pilots in training held the type ratings and the night VFR authorisation as well as the required level of experience in flight hours and hoist operations to be eligible for the SPA.HHO Initial training. Their level of experience was sufficient to benefit from a tailored SPA.HHO Initial training programme.

- The hoist operators in training had the required level of experience in flight hours and hoist operations to be eligible for the SPA.HHO Initial training. Their level of experience was sufficient to benefit from a tailored SPA.HHO Initial training programme.
- Both rescuers involved in the hoist exercises were up to date with the required training (provided by SAF HELICOPTERES) to perform this task.

1.17.8 DSAC oversight of operator

Within the scope of the AIR.OPS regulations, SAF HELICOPTERES is overseen by the DSAC for operations related to the AOC and SPO. The oversight includes audits, inspections and checks on topics such as the management system, the operator's operational bases, crew training, flight preparation, etc. The DSAC oversight actions are carried out over a period (cycle) set at 24 months for SAF HELICOPTERES, which is the standard cycle for a CAT operator. It is the DSAC-CE which is responsible for overseeing SAF HELICOPTERES.

Since the beginning of 2019, which corresponded to a change in the company's top management, the oversight actions (scheduled or unannounced) carried out by the DSAC had not revealed any level 1 findings[33]. Some oversight actions had revealed level 2 findings[34] which had been either corrected by the operator or were the subject of a corrective action plan drawn up by the latter. Communications between SAF HELICOPTERES and the oversight authority were described by the latter as "friendly and fruitful" since 2019.

1.17.9 Approval of HHO by the oversight authority

In order to be able to carry out SPA.HHO as part of CAT flights, SAF HELICOPTERES had submitted the draft OM including these operations as well as the associated training programme to the DSAC-CE Inspector in charge of the company. The Inspector in charge relies on the technical opinion of the NO-OH[35] and PN-EPN[36] divisions of the DSAC head office to grant the SPA.HHO approval. When no blocking points are identified, the Inspector in charge awards the approval for the activity concerned.

The OM version including SPA.HHO, initially submitted in September 2020, was modified several times by the operator following unfavourable opinions from the DSAC services before obtaining the SPA.HHO approval on 4 December 2020 in the absence of blocking points identified by the DSAC services.

Note: this iterative process is not unusual when setting up new approvals. SAF HELICOPTERES was the first French operator to ask for this approval.

In parallel, there were several exchanges between the DSAC and SAF HELICOPTERES (confirmed by both organisations) during which it was indicated that the crews concerned by the first training session were experienced in hoist and mountain rescue operations. As a consequence, the DSAC did not identify any blocking point in the final version of the OM including SPA.HHO and the Inspector in charge approved this activity.

Nevertheless, the PN-EPN had made some comments, particularly with respect to the training programme which would have to be improved (and more specifically, details about the flights for

[33] Significant non-compliance which lowers safety or is a hazard for flight safety.
[34] Non-compliance with the regulatory framework which could lower safety or present a potential hazard for flight safety.
[35] Operation Airworthiness - Helicopter Operations.
[36] Aircrew - Aircrew Expertise.

the SPA.HHO “Advanced Mountain” and “Advanced Night” sections), based on the feedback from the first training sessions completed. These comments were to be forwarded to SAF HELICOPTERES by the Inspector in charge in the days following the obtainment of the approval via the exchange tool, METEOR. The accident occurred before these comments were brought to the attention of the operator.

1.17.10 Modifications to the OM and resulting constraints

The operator’s OM must be modified when, among other things:

- Updates are made to the organisation chart, the organisation or the list of personnel holding specific positions of responsibility at the operator.
- Procedures are modified or there are regulatory changes.
- New operations or types of operations and associated training are introduced.

The introduction of new operations or types of operation is usually the result of the company’s business departments positioning themselves in new business sectors in response to a customer demand (private or state in case of air rescue operations). As a result, the signing of new contracts implicitly includes a date for the implementation of these new operations. This date therefore becomes a deadline for the NPCT and the NPFO to implement crew training, draft the procedures associated with these new operations, modify the OM to meet regulatory requirements and obtain the DGAC departments’ approval for these new operations.

Depending on the complexity of these new operations, the workload for the NPCT and NPFO may increase very rapidly and come on top of the usual tasks if they do not have adequate human resources to absorb the workload. Furthermore, the time required, in particular that relating to the DSAC issuing the approval, cannot be reduced. Indeed, the modifications to the OM, especially the introduction of new procedures and training courses, need to be studied by various DSAC departments (DSAC NO-OH, DSAC PN-EPN) in order to ensure that the company still offers a sufficient safety level, that the procedures are robust and that the proposed training courses meet the required criteria.

As a result, training courses, which cannot start before obtaining the approval and must be completed before the new operations start, may be subject to substantial time constraints.

The start of the mountain rescue season was scheduled for 12 December 2020, with the implementation of SPA.HHO-approved crews. The available training period was therefore five working days (from 7 to 11 December).

In addition, there were adverse meteorological conditions forecast for at least two of the five days, and at least two crews (pilot and hoist operator) had to be trained.

1.18 Additional Information

1.18.1 Statements

1.18.1.1 Instructor pilot’s statement

1.18.1.1.1 First statement

The instructor said that the two morning flights were to assess the trainees and that the two afternoon flights were to practice emergency procedures. He specified that the two night flights had been scheduled.

He added that as the pilots already had experience in hoist operations, the purpose of the flights and SPA.HHO training was mainly to harmonise procedures and enhance pair work.

He indicated that as there was no weather station on the aerodrome, the meteorological conditions were assessed through direct observation from the airfield. Forecast charts (SIGWX) were consulted, and the use of smartphone weather applications helped to confirm the observations and forecasts. He specified that there was no significant meteorological phenomenon during the day and in the early evening of the planned flight period likely to compromise the flights.

For the first night flight, the take-off had taken place at approximately 16:25 and there were no problems during the flight. No clouds, fog banks or fractus clouds were detected.

For the second night flight, they took off at 17:00 and headed towards the same site as for the previous flight. He specified that during the climb to the exercise site, he and the pilot observed some fog banks and fractus clouds on the side of the mountain located to the north-north-east of the exercise site. They considered that these phenomena were not hazardous and would not interfere with the flight. He added that the meteorological conditions at the site and in the immediate vicinity were good.

He indicated that, on arriving at the exercise site, the pilot carried out the reconnaissance of the latter and then performed two racetrack patterns, during which the two rescuers were set down. The pilot hoisted on board the two rescuers during a final hoist operation.

He specified that the pilot initiated a left turn to leave the hoist operation site.

He added that during the accident flight he had clearly seen the lights of Albertville and Grésy-sur-Isère and that when the pilot left the area to return to the base, he had seen the lights of Grésy-sur-Isère on his left and those of Albertville ahead.

He explained that, according to him, there was no hazard, and that this was why he had turned around to inquire about the personnel at the rear and make a sign to them to indicate that it had gone well. When he turned to face forwards, he saw the trees coming at him and did not have time to take the controls. When he regained consciousness, he was lying in the snow and was injured. He confirmed that his seat belt had been correctly fastened at the time of the accident and was unable to explain how he had ended up in the snow out of his seat. He was able to call the SAF HELICOPTERES operations department to report the accident and request a rescue helicopter.

At that time, the sky was starry and there were no clouds. He indicated he took shelter under branches. He said that he heard the sound of the turbines stopping, and that he then called to check for survivors but got no answer. Then later he heard mobile phones ringing. According to him, the cloud layer appeared about 30 min after the accident.

He added that the daytime training area was different from the area chosen for night flights. He specified that the night area had been identified during the last flight of the afternoon and that this area had been chosen because it was close to the aerodrome but far enough away not to generate sound nuisance. He added that the personnel had worked in a cross-functional manner (one instructor paired with one trainee) for daytime flights, but that for night flights, as this was an assessment flight, the two trainees (pilot and hoist operator) had worked together, with the two instructors present only as observers to assess teamwork and the application of procedures.

He said that at the end of the third hoist operation of the first night flight, the cabin had misted up on closing the side door, but that the pilot managed to clear the mist easily by adjusting the ventilation.

Concerning the meteorological conditions, he specified that he had been informed of the forecasts and of the disturbance that was coming, but that, based on the observations made from the aerodrome during the day and before the first night flight, it was expected that the disturbance would not arrive until late evening and that there was therefore no reason not to perform the two night flights. The observations made during the first night flight and the absence of clouds during this flight had reinforced his belief that this disturbance would not interfere with the flight.

Regarding the accident flight, he thought that the pilot, on the way back to the aerodrome, descended too early and too fast, perhaps to pass under the fractus clouds, which could explain the collision with the trees. He believed that the pilot was heading towards Albertville (the town) before initiating the left turn that was supposed to take him to the aerodrome.

1.18.1.1.2 Additional information gathered in interviews/meetings during investigation

The instructor confirmed that the SPA.HHO programme transmitted to the trainees was the appropriate programme, and was designed for the trainees to obtain the SPA.HHO “Initial” and “Advanced Mountain” approvals taking into account their experience and substantiated the choice of the environment in which the training flights were to take place.

He also mentioned that he was asked to train and not to select the crews.

The instructor also confirmed that the night flights were part of the SPA.HHO training. Nevertheless, the purpose of these two flights was to assess the crew in order to tailor the programme for subsequent night flights.

With regard to night hoist operations, the instructor indicated that the purpose of this training for SAF HELICOPTERES was to enable pilots to finish, if necessary, mountain rescue operations started during the day which ran into the aeronautical night legal time, while abiding by the law. According to the instructor, this training had never been intended to allow night mountain rescue operations to be performed.

The instructor indicated that, in his opinion, the site chosen for the two night flights presented no particular difficulty.

He specified that on the second night flight, after take-off and during the climb, he observed light halos around the lights of the towns, which indicated a humid environment in the valley, but that this observation was not of a nature to call the continuation of the flight into question.

Once the helicopter was established on the return leg to Albertville aerodrome and the lights of Grésy-sur-Isère were ahead of him with those of Albertville (the town) on his right, he turned around to have visual contact with, and ask if all was well with the personnel in the rear.

He specified that during the third hoist operation, the pilot had informed him of a change in reference and direction in order to keep the lights in the valley on the right. Afterwards, the pilot had repositioned the helicopter in hover facing Marret refuge (i.e. facing south-east). He then initiated the left-hand turn and started to gain speed.

The instructor specified that contrary to the first night flight, there had been no plan to land in the vicinity of Marret refuge.

The instructor put down the difference in the paths observed for the racetrack patterns of the two flights to the synergy that can develop between the pilot and the hoist operator in the course of the procedure, as well as to the pilot's decision to remain more or less close to the exercise site based on the visibility of the latter, the surrounding references and the constraints associated with the terrain.

He specified that he had not had to intervene at any time during the two flights and that, in his opinion, flight safety had not been compromised.

The instructor indicated that the workload of a NPCT was very high. He said that the modifications to the OM associated with SPA.HHO operations and the design and implementation of the SPA.HHO training to meet regulatory requirements and obtain approval from the civil aviation authorities, had led to a not insignificant increase in workload, although this work had been principally carried out by the NPFO. This workload had been in addition to the NPCT's usual tasks. He specified that the many different types of helicopters in the company also contributed to the increase in the workload.

He specified that he worked long hours and that he had been working seven days a week at that time. However, he did not consider this to have been impactful on the flight and its organisation.

1.18.1.2 Statement of pilot who performed first night flight

The pilot indicated that theoretical training took place on 7 December and was delivered by the NPCT in line with the content described in the company's SPA.HHO training plan.

This theoretical part was punctuated by exercises focusing on the analysis of a hoist operation as well as on the specific phraseology to be used.

He specified that on the morning of 8 December, all the people who were to receive the practical training were present. Two pairs were formed, including one pilot in training and one hoist operator in training respectively. The next day, the pairs were supposed to be switched for the check flight. The pilot indicated that the NPCT held the briefing for the first flight, confirming the composition of the pairs and specifying that the working area for the day would be on the east side of the Grand Arc massif in order to reduce sound nuisance, and that the exact hoist operation positions would be defined once at the site.

The pilot added that Albertville aerodrome was not equipped with a weather station providing aeronautical information and forecasts and that, given the proximity of the working area to the aerodrome, the meteorological file consisting of the TAF and METAR messages was not consulted. He indicated that the conditions were directly observed from the SAF HELICOPTERES operations base.

He specified that a thin high cloud layer was visible. He added that a smartphone weather forecast application indicated a light north-easterly wind and deteriorating conditions in the evening.

He indicated that F-HJAF was configured to match the medical evacuation configuration with a single seat on the rear right side in the cargo area and lifelines installed on the cabin floor. He added that this was one of the standard configurations provided for in the OM; therefore, the weight and balance were, in his opinion, within the permitted flight envelope.

He indicated that the morning flights were carried out according to the planning. For the afternoon flights, the NPCT held the briefing, and the weather conditions and forecasts remained unchanged. Both flights were completed without any problems being reported.

The pilot indicated that the aeronautical night started at 17:20 (local time) and that the NPCT held the briefing for the night flight at 17:00 (local time). During this meeting, the NPCT discussed the following points:

- The exercise was to consist of setting down each of the two rescuers with the hoist (two hoist operations) and then recovering both rescuers simultaneously in a third hoist operation.
- After the return to base, the switch between pairs would be done with the rotor turning and the NPCT at the controls.
- The estimated flight time was approximately 30 min for each flight.
- Given the night conditions, the plan was to work on the western part of the Grand Arc massif in order to maintain good visual flight conditions, in particular using the lights of Albertville.

The pilot specified that the Météo-France weather forecast for the Savoie department published by the Bourg-Saint-Maurice met office, indicated deteriorating weather conditions in the early evening. He added that from the SAF HELICOPTERES premises, the meteorological conditions observed on the Grand Arc massif did not give rise to any particular concerns regarding the performance of the exercise under satisfactory flying conditions.

The pilot indicated that the engine start-up for the third flight was at 17:25 (local time) with 205 kg of fuel in the main tank. He took off on runway 05, initially climbed heading north-east and then continued towards the Grand Arc massif. He turned 180° to the right heading south-west towards the exercise area.

He specified that the dusk conditions had enabled him to see sufficiently clearly to search for the working area safely. He added that a partial cloud layer was clearly visible over the ridges rising to an altitude of approximately 2,300 m; nevertheless, this was posing no immediate threat. He stopped the climb at approximately 1,800 m, at the vegetation limit.

The pilot indicated that the chosen practice area was on a snowy knoll near Marret refuge, which could be used as a shelter for the rescuers, if necessary, in the event of a problem with their recovery.

He specified that he carried out a reconnaissance of the exercise hoist site to determine the various parameters for the arrival, hoist and departure phases; the estimated altitude of the hoist operation position was approximately 6,600 ft (2,000 m).

He added that the exercises took place without any problems, apart from the cabin starting to mist up when the rescuers boarded, and that opening the “clear-vision” window and switching on the cabin heating had resolved the problem.

He indicated that the NPCT asked him to land in the immediate vicinity of Marret refuge to end the exercise. The flying conditions were excellent despite the dark night. Afterwards, the pilot headed towards Albertville aerodrome and landed on runway 05. The crews switched with the rotor turning as planned; the remaining fuel on board was then 125 kg.

During a subsequent telephone conversation, the pilot specified that he had received the training programme by e-mail on 4 December and that he considered night flight as being part of the SPA.HHO helicopter hoist operation training. He was supposed to start the mountain rescue season at the end of the week[37] and was not aware of any additional night flight session as part of the SPA.HHO “Advanced Night” training.

1.18.1.3 Statement of hoist operator in training who performed first night flight

He specified that the daytime flights had taken place in accordance with the scheduled programme. He added that in the morning, deteriorating weather conditions had been forecast for Tuesday night, but that this had not called into question the afternoon programme.

He indicated that for the night flights, after a briefing and presentation of the exercise, the disturbance which had been mentioned during the day was visible. However, the cloud base was high enough to allow the flights to take place. He added that it was agreed that the execution of the mission would be adjusted in the event of a change.

He specified that, as part of night flights and to ensure maximum visibility, the helicopter’s two headlights were used, and that a light strip was attached to the hoist hook.

He indicated that after the take-off and climb to the Marret refuge, he observed that the cloud base was level with the summit of the Grand Arc massif and would not hinder the flight. He indicated that once at the exercise site, visibility was good with no precipitation or formation of clouds and that there was residual brightness. He added that the three hoist operations and the return to Albertville aerodrome had taken place without any problems and that the crews switched with the rotor turning as planned during the briefing.

He indicated that the debriefing for the night flights was scheduled to take place the next morning before the check flight.

1.18.2 Meeting with mountain rescue and hoist operation experts

A meeting was held at the BEA on 14 June 2022 with mountain rescue and hoist operation experts from State entities, private operators providing rescue services, including SAF HELICOPTERES, and the DSAC. During this meeting, the factual aspects of the investigation were presented, leading to discussions and the sharing of opinions with regard to “best practices”.

[37] Given the COVID-19 pandemic and the national measures affecting winter sports resorts, mountain rescue operations were cancelled.

Concerning the execution of the training and the tailoring of the programme, it appeared that simultaneous training of the pilot and the hoist operator was not common practice. The decision to provide the “Initial” and “Advanced Mountain” training courses simultaneously for daytime flights was understandable given the experience already acquired by the trainees.

For the night flights, reservations were expressed concerning the level of experience of the pilot in training with regard to the site chosen and the mission’s complexity: dark night in a mountainous region and potentially deteriorating weather conditions. The pilot in training was perceived to have a small amount of experience in terms of notably the low number of flight hours carried out at night, given that most of the night flights over the last few years had been cross-country flights for the SAMU or the return flight after a mountain rescue mission to the Courchevel base at dusk (just after the start of the aeronautical night).

Regarding the flight paths followed between each hoist operation, the difference between the two night flights revealed two different manoeuvring decisions: during the second flight, the times (almost identical to those of the first flight) indicated that the pilot flew in a smaller perimeter at lower speeds and with larger bank angles during the turns, which, at night and with few visual references, could lead to a feeling of “discomfort” and a more “bumpy” flight. In addition, it appeared that the racetrack patterns performed left little margin in the event of technical failures (e.g. engine failure).

Furthermore, when an instructor is assessing or training a pilot, it would appear more pedagogical to consolidate the working methodology with standard manoeuvres and to avoid manoeuvres which do not offer a sufficient safety margin in the event of something unexpected happening.

It was confirmed, through the experience of the participants working for a commercial operator, that the NPFO and the NPCT positions consistently have a high workload and that a lack of human resources (deputies) can be critical, especially when new operations, new training courses or new aircraft are introduced. The variety of tasks attached to these positions means that NPCTs and NPFOs are almost constantly called upon, often with no time to lose, which may result in them not being able to devote the required level of attention during check or training flights, for example.

1.19 Useful or effective investigation techniques

One specific feature of the accident site was its location in a mountainous environment. Access was difficult and the snow coverage was substantial. Moreover the weather forecast in the days following the accident was generally adverse.

After travelling to the site by helicopter on 10 December 2020, taking advantage of a favourable weather window, and making initial observations, the decision was made to recover the wreckage at a later date and transport it to the BEA’s facilities at Le Bourget. A full examination under optimal conditions could then be carried out.

The recovery took place on 21 and 22 April 2021, when the area was still very snowy. Given the absence of a track suitable for vehicles and the presence of a still substantial snow coverage, the wreckage had to be transported by helicopter. The wreckage was substantially damaged, so the heaviest main part could in theory have been transported by an AS350 helicopter. However, the operator in charge of the recovery operation opted for an AS332, which offered much higher capabilities and was, in theory, oversized. This decision proved to be crucial to the success of the operation: all the available power had to be used due to the presence of a large layer of ice under the wreckage which was holding it back.

The elements of the wreckage were then transferred to the valley and placed on a specially chartered trailer from a specialist company. The latter travelled to Le Bourget, where the wreckage was conserved in the BEA's facilities.

Figure 27: photo of recovery operation (source: BEA)

2 ANALYSIS

2.1 Introduction

On 8 December 2020, the flight schedule for the EC135-T1 registered F-HJAF, operated by SAF HELICOPTERS involved six training flights: two morning flights, two afternoon flights and two night flights.

This training was carried out in the scope of a specific approval for commercial air transport hoist operations (SPA.HHO). It followed the approval obtained from the French civil aviation safety directorate (DSAC) on 4 December and was delivered in order to have qualified crews for the start of the mountain rescue season scheduled for 14 December, for which SAF HELICOPTERES had obtained a commercial contract.

The training provided was to enable the operator to use the hoist during emergency medical flights in the mountains.

This first training session involved two crews, each consisting of a pilot and a hoist operator. They all had recognised hoist operation experience in mountainous regions in daytime.

At the end of the afternoon, the two crews held a briefing before the two night flights. The review of the weather forecast had revealed that there would be a disturbance bringing snow in the evening. Given the arrival of this disturbance, the very short exercise programme (three hoist operations) and the proximity of the exercise site (situated at 3.2 NM south-east of the aerodrome at an altitude of 1,820 m), all the persons concerned took the decision to carry out the two flights one after the other and to switch crews with the rotor turning at the end of the first night flight.

For these two night flights, the crew on board was made up of an instructor pilot, a pilot in instruction, an instructor hoist operator, a hoist operator in training and two rescuers who were taking part in the hoist operations. The pilot and hoist operator training was combined instead of being carried out separately as had been the case in the daytime flights. The instructor indicated that the purpose of these two night flights was to assess the crews.

After the first night flight, the first crew (pilot in instruction and hoist operator in training) was replaced by the second pair. The instructor pilot, the instructor hoist operator and the two rescuers remained on board during this switch over.

The second pilot in instruction took off at 17:00 from Albertville aerodrome bound for the exercise site. Having arrived at the area, the pilot carried out the same exercises as during the previous flight.

At the end of the third hoist operation and after the door was closed, the pilot initiated a left-hand turn. The analysis of the flight path followed to leave the exercise area shows that the pilot headed roughly north-west while accelerating. It was at this point that the instructor turned to the other four occupants located at the rear of the helicopter. According to the instructor, the flight path was stabilised and there was no obvious risk before he turned around.

The path data shows that the helicopter initiated a left-hand turn which continued through 180° while remaining in level flight. The path taken led the helicopter towards the mountainside; it collided with the vegetation, then with the ground.

The examination of the wreckage, maintenance documentation and data recorded by various computers did not reveal any malfunction of the helicopter likely to explain the accident.

The evidence gathered suggests that the helicopter was controlled until the collision.

The following analysis focuses principally on the operational and organisational circumstances in which the accident flight took place.

2.2 Comparison of the two night flights and the different hoist operations

The two night flights were similar in theory. They were expected to last approximately 30 min. However, the analysis of the flight paths followed revealed substantial differences. The path followed to reach the exercise area was essentially the same for both flights. However, during the reconnaissance and hoist operation phases, the pilot of the second flight flew much tighter paths than the pilot of the first night flight.

During the first flight, the pilot flew in an area approximately 1,500 m in diameter for the reconnaissance and 800 to 1,000 m for the hoist operation phases, which, in accordance with his statement, meant that he still had sufficient ambient light to make out the terrain and position the helicopter at the exercise area while carrying out the racetrack patterns as described in the SPA.HHO procedures of the OM.

During the accident flight, the flight paths were tighter (about 600 m for the reconnaissance phase and the first two hoist operations, and then only 300 m for the third hoist operation). The flight path data indicates that the pilot performed two patterns before starting this final hoist operation. The manoeuvring speed was also lower. The time spent at the exercise site was approximately 7 min and 30 s (from the end of the reconnaissance to the departure from the site). The first two approaches and the two hoist set-down operations lasted 3 min and 40 s. The approach for the hoist recovery operation lasted 3 min and 20 s, and the hoist recovery operation lasted between 50 and 60 s.

During the racetrack pattern for the third hoist operation, the instructor indicated that the pilot of the accident flight told him that he thought he was incorrectly positioned, and that he was starting the approach again to position the helicopter at the recovery point of the two rescuers. The instructor specified that the manoeuvres performed by the pilot in training, although tight, had not involved any particular risks. He did not detect any problems during the different hoist operations and did not have to make any input on the flight controls.

The investigation could not determine whether the flight paths recorded during the exercises of this second night flight were indicative of any specific problem, in particular whether the pilot in training had been experiencing latent difficulties since the beginning of these night exercises, whether his flying performance had deteriorated during the third approach, or whether he had been trying to adapt to changing environmental conditions or the dark night.

2.3 External visual references

The accident flight was a local flight (distance less than 6.5 NM) in uncontrolled airspace, from an uncontrolled aerodrome, and without a weather station to assess the conditions at the aerodrome. As a result, the pilots were responsible for assessing the meteorological conditions to determine whether they could take off and perform the flight.

The second night flight was undertaken based on the weather conditions observed by the persons on board the helicopter during the first night flight, which confirmed the initial decision taken before the night flights.

Taking into account the statements of the instructor and of the pilot in training during the first night flight, as well as the recorded temperature parameters, it appears that the meteorological conditions at the time of the accident flight were better than those indicated by the forecast weather charts.

Nevertheless, ahead of the disturbance, due to lower temperatures and higher humidity, it is possible that local phenomena may have developed on the mountainsides, such as mist or fog banks or fractus cloud banks close to the terrain.

The night of the accident, the moon had not risen and the night was thus dark. Although the town lights in the distance were visible, they were only sufficient for choosing a heading or determining a position with respect to remote reference points. The dark, moonless night would have made it very difficult for nearby terrain to be discerned. The helicopter lights, while manoeuvring at low speed or in near-hover were needed to distinguish and avoid obstacles close to hand. The pilot could only make out the surrounding terrain by means of the light beam projected by the helicopter's headlight In addition, in the previous days, snowfalls had completely covered the ground and vegetation in this area making it particularly difficult to distinguish potential cloud banks and to assess their proximity.

Moreover, it is possible that local cloud or fog banks, even if they were not in the exercise zone, could have concealed some of the lights of Albertville or nearby villages in the valley on leaving this area.

The elements gathered in the instructor's statement do not make it possible to determine with accuracy, the meteorological conditions prevailing during the accident flight, either in the exercise area or on the outbound and return legs, essentially because of the confusion the instructor may have experienced as a result of the accident. However, the instructor specified that before turning around, the flight path had appeared to be safe. It is unlikely that the instructor would have turned around, and in so doing, ceased monitoring the flight parameters, if he had detected an abnormal or potentially hazardous situation such as the loss of external visual references. Furthermore, the instructor indicated that the pilot had not reported any problems or unusual situations to him at that time.

On leaving the exercise site at night, the pilot was expected to fly in a direction that would allow him to check that there were no obstacles on the planned flight path; the helicopter lights were no longer the main means to be used to identify the route to be taken or to avoid obstacles.

2.4 Navigation aids available during night flights

The helicopter registered F-HJAF was equipped with a HELIMAP GNSS map-based positioning system and with functionalities that allowed users to define specific positions such as Albertville aerodrome and the exercise site, as well as to display the route to be followed between these positions.

Working practices within the company and the different types of missions performed (helicopter external sling load operations, mountain rescue, human cargo operations or HEMS), which are carried out during the day in areas that the pilots are familiar with, means that the HELIMAP tends not to be used during mountain rescue flights. The map library installed only offers one 1:500,000-scale base map with relatively few details compared to the navigational precision required for the missions carried out.

The night flights carried out by SAF HELICOPTERES were principally cross-country or HEMS hospital-to-hospital flights where, apart from the landing and take-off phases, the flight heights chosen clear obstacles. The routes and ground references (town lights) are known and easy to identify, and the conventional radio navigation means or GNSS are appropriate for the type of flight. The HELIMAP system, if used, was only a supplement for path and flight management.

If a night helicopter hoist operation is performed in a mountainous area below the terrain ridges, in the absence of conventional radio-navigation means and easy-to-identify visual references, a positioning system such as HELIMAP can be an additional aid for the pilot to locate himself in relation to the surrounding terrain and obstacles and to define a safe route to follow. However, the map base used needs to be appropriate for the operations. Regarding F-HJAF, if the pilot had used HELIMAP, proximity to obstacles and terrain would have been difficult to detect given the level of detail shown on the available map (ICAO VFR map to a scale of 1:500,000). However, selecting Albertville aerodrome as the destination point would probably have given the pilot an indication of the route to be followed.

2.5 Situational flying experience

At the time of the accident flight, the pilot in training, given his seniority within the company, probably had good daytime knowledge of the area and surrounding references. However, he had little experience of night flight. Moreover, it is probable that the night experience he had acquired was principally based on air ambulance or ferry flights. As a consequence, the pilot was probably acquainted with the light references corresponding to the conventional routes and surroundings of the aerodrome. It is likely that he was less at ease identifying or keeping track of them outside these known environments, in particular, near the terrain.

In addition to the visual references specific to the region, night flight, especially in the mountains, is more exposed than day flight to certain risk factors such as a reduction in visual performance, visual aberrations or spatial disorientation[38].

Although it does not eliminate these risk factors, situational experience usually provides better protection against them. The instructor may have overestimated the pertinence of the night flight experience of the pilot in training with respect to the intended training flight, which presented particular difficulties (flying close to mountainous terrain in moonless night conditions).

[38] See paragraph 4 of the guide *VFR de nuit en hélico*.

Reservations about the previous experience of the pilot in training expressed during the meeting with mountain rescue and hoist operation experts held at the BEA are consistent with this opinion.

2.6 Safety management

SAF HELICOPTERES had been carrying out mountain rescue hoist operations for several years, in compliance with the operational rules of a national order. When mountain rescue operations were activated at the end of the day, pilots had to make the return flight at night. SAF HELICOPTERES indicated that it had chosen not to carry out rescue operations at night even though it was authorised to do so by the national order. This operations restriction which SAF HELICOPTERES imposed on itself was not clearly mentioned in its Specific activities manual.

Regulatory changes at European level (AIR-OPS regulation) led the operator to apply for SPA.HHO approval in order to be able to carry out hoist operations as part of emergency medical evacuation flights by day and night. SAF HELICOPTERES specified to the BEA during the investigation, that the operational objective was to be able to finish mountain rescue operations started at the end of the day, after nightfall. There were no plans to initiate helicopter hoist operations at night. This operations restriction, which SAF HELICOPTERES indicated it wanted to impose on itself, was not clearly mentioned in the company's OM. The regulations require the operator to define an appropriate training plan corresponding to the planned SPA.HHO operations, which must be included in the OM. Once the civil aviation authorities have given the SPA.HHO approval, the operator is required to observe and comply with the procedures in the modified OM.

When the authority gives its approval, this normally means that the operator has been able to demonstrate, through the provisions it has made, its ability to meet the regulatory requirements, and to guarantee a sufficient safety level to perform the operations in question.

However, the investigation showed that SAF HELICOPTERES had not clearly defined the operational objectives underlying its wish to obtain the SPA.HHO approval. For example, it was not clear whether night mountain rescue services were envisaged, and if so, under what circumstances. In this regard, the OM (Part D) stated that a pilot holding the “Advanced HHO” rating could carry out any type of emergency medical service mission using the hoist in a mountainous area, including at night. The corresponding training was described as supplementing the pilot’s training and experience in the environment in question. According to the instructor, who was also the NPCT, the purpose of the “Advanced Night” training was only to enable crews to reach their base in good conditions, if a mission initiated during the day extended into the aeronautical night.

While the first flight carried out on the day of the accident at nightfall could fall into this operational framework, the second flight carried out when the night was fully established, with no moon, introduced additional difficulties which went beyond the operational framework mentioned by the instructor and by SAF HELICOPTERES.

The lack of precision concerning the operational context envisaged after obtaining the SPA.HHO approval raises the question as to the basis on which SAF HELICOPTERES:

- Carried out the safety impact assessment for the SPA.HHO approval.
- Defined the associated training and determined that the pilots in training had enough experience - in particular night flight experience - for them to follow this training.

The risk map drawn up by SAF HELICOPTERES suggests that the safety impact assessment:

- Was not taken as an opportunity to explore the risk factors specific to both night and mountain operations.
- Focused almost exclusively on the hoist operation phase which characterises SPA.HHO operations, without explicitly addressing the arrival at and departure phases from the mission site, which involves forward flight close to the terrain.
- Did not include a section specific to training flights undertaken as part of this SPA.HHO approval.

The initially assessed risk level for nine of the ten hazards identified in the impact assessment, was reduced by the various safety barriers listed. Crew experience was proposed as a barrier to address three of the identified risks, and crew training as a barrier to address six of them. A lack of training and recent experience was a hazard in its own right in the SPA.HHO risk map developed by SAF HELICOPTERES.

The risk analysis was not extended beyond the map. The expected scope of the barriers listed in this map was not specified either.

The changes involved by the performance of operations under SPA.HHO approval had been considered acceptable in the final assessment of the overall risk level.

When the helicopter collided with the terrain, the hoist exercise had ended, and the pilot in training was expected to head back to the aerodrome. From this point of view, it could be considered that the accident does not correspond to a risk specific to the SPA.HHO approval. Nevertheless, the accident brought to light two risk factors specifically related to the context of the SPA.HHO training programme:

- Flight in direct proximity with the terrain, in a mountainous area and at night, in natural light conditions in which it was not possible to distinguish close obstacles, constituting an environment for which the experience of the pilot in training was probably overestimated.
- A flight which combined the pilots’ training and the hoist operators’ training, i.e. in a context likely to increase the number of unforeseen events, the points requiring attention and the needs for coordination between the cockpit and the rear section of the helicopter.

These specific risk factors had not been anticipated by SAF HELICOPTERES in the safety impact assessment carried out to obtain the SPA.HHO approval.

2.7 Context of the two night training flights

This was the first SPA.HHO training session organised by SAF HELICOPTERES. This followed the approval obtained three days earlier. The instructor pilot (who was also the NPCT) and the instructor hoist operator (who was also the NPFO) were the only two people trained to deliver the training they had set up.

The SPA.HHO training programme submitted by SAF HELICOPTERES and approved by the DSAC-CE included, under certain conditions, the option to tailor the SPA.HHO “Initial” training to the experience of the trainees. The investigation showed that the pilots and hoist operators in training had the necessary prerequisites to follow the SPA.HHO training provided by SAF HELICOPTERES. Moreover, they were eligible for tailored SPA.HHO “Initial” training. However, there was no record of this verification by SAF HELICOPTERES.

The daytime flights carried out on 8 December revealed that:

- The two “Assessment” and “Norm/Sec Proc” daytime flights took place in a high mountain area and simultaneously included the exercises normally studied during the flights defined in the SPA.HHO “Initial” and “Advanced Mountain” training.
- Given the strategy of division of roles on board[39], the flight times and the number of hoist operations carried out by the trainees were less than that specified in the SPA.HHO “Initial” and “Advanced Mountain” training programmes.
- The SPA.HHO “Initial” and “Advanced Mountain” programmes were merged although this was not provided for by the OM.
- The two night flights (including the accident flight) came under the SPA.HHO training programme.
- The two night flights were carried out in a mountainous environment although the trainees had not validated either the SPA.HHO day “Initial” or “Advanced Mountain” training programmes.

The training programme specified in the OM, even if tailored, did not provide for the option of merging and/or delivering initial and advanced training courses simultaneously, nor of reducing the number of flights for the advanced training. The flight training programme undertaken on 8 December thus did not correspond to the SPA.HHO training programme submitted by SAF HELICOPTERES and approved by the DSAC, even if we take into account the tailoring possibilities provided for in this programme.

The instructor confirmed that given the experience of the personnel to be trained (number of flight hours, number of hoist operations, experience in mountain rescue during the previous seasons), the training programme sent to the trainees on Friday 4 December included the tailoring of the flight part of the SPA.HHO “Initial” training and its merging with the SPA.HHO “Advanced Mountain” training. However, he did not confirm that this strategy also applied to the SPA.HHO “Advanced Night” training.

The objective of the two night flights, including the accident flight, could not be clearly defined during the investigation. Indeed, although these flights had been recorded in the SPA.HHO training flight schedule and the flights were carried out according to this schedule, the statements gathered from the instructor as well as from the pilot and the hoist operator of the first night flight do not completely corroborate with each other as to the objective of these flights:

- During the investigation, the instructor stated that these night flights were part of the SPA.HHO “Advanced Night” training, but that these were assessment flights to determine the content of subsequent night flights.
- According to the pilot of the first night flight, the training programme received by e-mail on Friday 4 December did not suggest that night training flights were planned after those scheduled on 8 December.
- According to the hoist operator of the first night flight, this flight was part of the training programme.

[39] As they work alternately, only half of the total hoist operations carried out and half of the airborne time at the exercise site can be attributed to each trainee. The flight time to and from the site was deducted in full.

In any event, as the pilot in training during the accident flight had not yet acquired the SPA.HHO "Advanced Mountain" and "Advanced Night" ratings, the accident flight could only be formally carried out under the supervision of the instructor as part of the SPA.HHO "Advanced Night" training.

Furthermore, the crews had carried out more than 50 hoist operations, which, provided they held the SPA.HHO "Advanced Mountain" approval, would have allowed them to carry out mountain rescue (air ambulance) missions including daytime hoist operations. For night mountain rescue (air ambulance) missions, the crews were required to hold the SPA.HHO "Advanced Night" approval and to have carried out 20 night hoist operations including 3 in the last 90 days. These requirements were set out in the operator's OM.

The programme for the night flights consisted of three hoist operations, which met the recent experience requirements.

However, the software used by the operator did not record the number of night hoist operations carried out (and in particular, those carried out by the pilot in training during the accident flight). Nor did the analysis of the information logged in the pilot's logbook make it possible to determine the number of night hoist operations carried out over the last three years. Even if it appears that during mountain rescue missions he had performed in previous years, several hoist operations had started during the day and ended at night, it was not possible to determine whether the hoist operations had taken place by night or whether the night flight time logged in the logbook only corresponded to the return cross-country flight to the base. It was therefore not possible to determine whether the pilot had already carried out night hoist operations in the past and how many.

Beyond these considerations of regulatory compliance, it appears that, in the opinion of the experts in mountain rescue and hoist operations brought together by the BEA on 14 June 2022, the pilots in training had prior experience enabling them to follow the training flights carried out during the day. On the other hand, the night flight experience of the pilot in training at the time of the accident, acquired mainly during EMS cross-country flights and during return flights from rescue missions to the Courchevel base after the aeronautical night had started, was probably low with respect to the specific difficulties of the planned training flight, in direct proximity with the terrain, in a mountainous area and at night, in natural light conditions in which it was not possible to distinguish close obstacles.

2.8 Contractual stakes and associated constraints

The introduction of SPA.HHO operations and the implementation of the associated training within SAF HELICOPTERES required a substantial modification of the OM. The modified version of the OM incorporating the SPA.HHO operations was submitted to the DSAC departments for approval in September 2020. It underwent several modifications in the course of discussions with the authority.

SAF HELICOPTERES obtained the approval for SPA.HHO operations from the DSAC on 4 December 2020. The mountain rescue season was scheduled to start on 12 December 2020. At least two crews (pilot and hoist operator) had to be trained by this deadline. The possible training period was therefore five working days (from 7 to 11 December), the first day being dedicated to the theoretical training.

The time constraint that emerged at the end of the project and the adverse weather forecast on two of the four days available to carry out the SPA.HHO training flights probably led the RDFE and the RDOV to propose a condensed programme over a reduced period of time with little room for manoeuvre on the date for carrying out the night flights.

Furthermore, given the contractual stakes, obtaining the SPA.HHO approval and the resulting crew training was a major project for the company taking up a period of several months. The NPCT and the NPFO were considered as the key players in this project, as they were expected to take part in multiple activities, in particular:

- contribute to the safety impact assessment;
- develop the training plan and update the OM;
- exchange with the DSAC in order to obtain approval;
- tactically organise and deliver the first training session in full, as *primo* instructors.

Recruited only four months before the accident, the NPCT also had, within this short space of time, to familiarise himself with:

- the resources and practices of his new employer;
- the tasks that were assigned to him as NPCT;
- the scope of operations specific to civil aviation;
- an operating environment that was new for him.

The company’s management was probably unable to identify or appreciate the pressure induced by the contractual commitments, and the pressure which its accountable managers, and in particular the NPCT and NPFO put on themselves. This pressure may have led to them deviating from the conformity requirements which they normally guarantee and may have compromised their ability to effectively manage certain risks.

In particular, it is probable that they overestimated the night experience of the pilot in training in the accident flight with respect to the hazards associated with a night flight in a hostile environment (mountains, dark night, forecast deteriorating weather conditions).

3 CONCLUSIONS

3.1 Findings

3.1.1 SAF HELICOPTERES

- The company had an Operations Manual (OM) that included helicopter hoist operations in commercial air transport flights (SPA.HHO approval).
- The modified OM incorporating the SPA.HHO operations was considered by the DSAC-CE to comply with the regulatory requirements and it approved the latest version of the OM on 4 December 2020.

3.1.2 EC135-T1 registered F-HJAF

- The helicopter was approved by the DSAC-CE on 4 December 2020 to carry out helicopter hoist operations under day and night VFR conditions, with the regulatory waiver CAT.POL.H.305 "Operations without an assured safe forced landing capability".
- The examination of the helicopter's maintenance documentation did not reveal any anomaly or latent fault that could have restricted its use.
- The helicopter was within the weight and balance envelope permitted by the manufacturer.
- The performance of the helicopter, taking into account the conditions of the day and the load (equipment, on-board personnel, fuel), allowed the flight to take place.
- The analysis of the general parameters recorded by the various on-board computers did not reveal any malfunction during the flight.
- The examinations carried out on the helicopter wreckage did not reveal any malfunction likely to explain the accident.
- Based on the analysis of the engine parameters from the on-board computers, it could be concluded that:
    - the variations in the engine parameters during the day, and more particularly during the two night flights, were consistent with the description of the flight profiles and phases indicated in the statements and the information logged in the technical logbook;
    - the operation of both engines was nominal during the second night flight up to the second collision with the trees;
    - the occurrence of the same "Collective Pitch" failure on both engines, just before the almost simultaneous stop of the two engine control units, coincided with the second collision with the trees, which led to the destruction of the cockpit and the control linkages.
- The almost simultaneous shut-down of both engines was due to the ingestion of snow and vegetation debris that were found during the examination of the wreckage.

3.1.3 Personnel on board

- The instructor pilot had the ratings and experience necessary to supervise a night instruction flight in accordance with the regulatory requirements and those set out in the SAF HELICOPTERES procedures.
- The pilot in instruction had the ratings and recent experience necessary to carry out night flights and follow the helicopter hoist operation training as defined in the OM.

- The instructor hoist operator had the ratings and experience necessary to provide the hoist operator training during a night flight.
- The hoist operator in training had the ratings and experience necessary to follow helicopter hoist operation training.
- Both rescuers had the required experience and had received the necessary training from SAF HELICOPTERES to participate in day and night helicopter hoist exercises.

3.1.4 Training programme

- The SPA.HHO training programme submitted by SAF HELICOPTERES was approved by the DSAC-CE on 4 December 2020.
- The content of the SPA.HHO training programme met the SPA.HHO regulatory requirements.
- The theoretical training delivered on Monday 7 December 2020 was in line with the training programme specified in the OM.
- The practical flight training delivered on Tuesday 8 December 2020 did not follow the different steps of the SPA.HHO training programme described in the OM.
- The SPA.HHO “Initial” and “Advanced Mountain” training modules were carried out simultaneously; this configuration was not provided for in the SPA.HHO training programme.
- The night flights performed on 8 December 2020 came under the SPA.HHO “Advanced Night” training.

3.1.5 Meteorological information

- The various weather forecast charts indicated the arrival of a snow disturbance with low clouds in the evening.
- The 15:00 SIGWX chart indicated that the Albertville region was not yet affected by the snow disturbance. The 18:00 chart showed that the front limit of this disturbance affected the Albertville region.
- The statements gathered indicated that at 16:30, the snow disturbance was not present and that the visibility and ceiling were compatible with carrying out the flights.
- The satellite images showed the progress of the disturbance (yellowish mass indicating low-altitude clouds) and in particular, that between 17:00 and 17:30, the exercise area was progressively affected by this disturbance. Due to the lack of images at the time of the accident (17:15), it was not possible to determine precisely whether or not these low clouds were present. Nevertheless, the exercise area was probably subject to preceding phenomena of the disturbance associated with mountainous environments and night conditions.
- During the second night flight, the instructor observed banks of mist and fractus clouds in the valley and on the northern side of the Grand Arc massif.

3.1.6 Accident sequence

- The two hoist operations to set down the two rescuers one after the other, and the hoist operation to pick up the two rescuers together took place as planned.
- The pilot left the exercise site in a north-westerly direction while gaining speed before turning left.
- The left-hand turn was continued through around 180°.
- The rotor and the front of the helicopter struck two isolated trees.

- The ingestion of vegetation debris and snow by both engines caused the engines to shut down nearly simultaneously.
- The helicopter collided with a second very dense group of trees which resulted in the destruction of the front of the helicopter and the separation of the side doors.
- During the collision with these trees, the instructor in the front left seat was ejected along with his seat from the helicopter.
- The helicopter struck the snow-covered ground and came to a stop in the snow.

3.1.7 Survival aspects

- Given the damage to the helicopter observed at the accident site and in the workshop, there was no chance of the helicopter's occupants on board at the time of the final collision with the ground, surviving the accident.
- The instructor's survival can be explained by the fact that he was ejected from the helicopter during the last collision with the trees, the very low height at which this occurred and the thickness of the snow cover on the ground, which cushioned the fall.
- The instructor and the pilot had their seat belts fastened. The other four people on board were most likely attached to the helicopter through their harnesses.

3.2 Contributing factors

After a flight described by the instructor as an assessment flight as part of the night helicopter hoist operation training, the pilot left the site and made a left-hand turn of approximately 180° while remaining in level flight. The flight appeared to be controlled until the collision with the trees. It was not possible to determine the reasons why the pilot initiated this turn. It cannot be ruled out that this turn was initiated to avoid clouds and fog banks which had appeared near the exercise site.

It was not possible to determine the exact reasons why the pilot continued the left-hand turn until the collision with the trees and then the ground. This could be explained by the pilot losing situational awareness regarding the position of the helicopter in relation to the terrain.

The following factors may have contributed to the pilot's possible loss of situational awareness of the position of the helicopter in relation to the terrain:

- The partial or total disappearance of the distant reference points formed by the town lights in the valley due to the deterioration of the weather conditions.
- The loss of external visual references in the final phase of the flight path due to reduced light conditions on a dark, moonless night, which did not allow the pilot to make out obstacles and the surrounding terrain.
- The instructor temporarily suspending his monitoring of the flight path in a context where the pilot had limited recent and total night flight experience with respect to the specific difficulties of this flight phase, in immediate proximity with the terrain in dark night conditions in which it was not possible to distinguish close obstacles. As they moved away from the hoist operation site, the instructor considered the path initiated to be consistent with a safe return to the aerodrome, and turned around to exchange with the other occupants of the helicopter.

It cannot be ruled out that a sensory illusion phenomenon during a dark night may have contributed to the pilot possibly losing situational awareness of the position of the helicopter in relation to the terrain.

The following factors may have contributed to the decision to undertake an instruction flight with reduced safety margins in a hostile environment (mountain, dark night, deteriorating weather conditions forecast):

- Insufficient consideration given to the pilot's little recent and total night flight experience in a mountainous environment in immediate proximity with the terrain.
- Underestimation of the flight risks potentially caused by the time constraint to complete the training. This constraint could be explained by the desire to have qualified crews available to meet the requirements for mountain rescue operations the following week. This may have led the instructor/NPCT to propose a shortened training programme that was supposed to enable the trainees to obtain all the SPA.HHO approvals, although this situation was not provided for in the OM. While SAF HELICOPTERES may have considered that the pilot's experience in daytime mountain flying allowed for this shortened programme, this reasoning does not seem to be transposable to night training flights.

The following factors may have contributed to the accountable managers, and in particular the personnel in charge of setting up the SPA.HHO operations putting pressure on themselves:

- The company's management (including the instructor hoist operator responsible for flight operations and the instructor pilot responsible for crew training) insufficiently taking into account the time necessary to include SPA.HHO procedures in the OM and for the civil aviation authorities to give its approval of these operations, given the planned contractual dates for setting up these operations.
- The work overload generated by the setting up of SPA.HHO operations and the associated training.

3.3 Safety lessons

Compliance with the Operations Manual (OM)

From the first training sessions carried out, the instructor pilot - the Nominated Person for Crew Training (NPCT) and in charge of implementing and arranging training to obtain the specific approval for helicopter hoist operations - deviated from the training programme specified in the OM.

The instructor confirmed that given the experience of the personnel to be trained (number of flight hours, number of hoist operations, experience in mountain rescue during the previous seasons), the training programme sent to the trainees on Friday 4 December included the tailoring of the flight part of the SPA.HHO "Initial" training and its merging with the SPA.HHO "Advanced Mountain" training.

The SPA.HHO training programme specified in the OM, even if tailored, did not provide for the option of merging and/or delivering initial and advanced training courses simultaneously, nor of reducing the number of flights for the advanced training.

The minimum basic principle is to adhere to the OM, drawn up after a safety analysis, for training crews and for carrying out all the specified operations.

The OM must be seen by all the operator's personnel as a tool to help them carry out flights safely, and the nominated persons who actually drew it up should especially force themselves to comply with it scrupulously. Compliance with the OM could also be a means of resisting time and financial pressures for those in charge of its enforcement.

4 SAFETY MEASURES TAKEN SINCE OCCURRENCE

SAF HELICOPTERES SPA.HHO approval

The day after the accident, the DSAC-CE suspended the SPA.HHO approval delivered to SAF HELICOPTERES.

On 5 January 2021, SAF HELICOPTERES, after having made modifications to the SPA.HHO training programme, asked the DSAC-CE to lift the suspension of approval.

On 26 January 2021, the DSAC-CE lifted the suspension for daytime operations.

Organisation of SAF HELICOPTERES

Since the accident, SAF HELICOPTERES has changed the organisation with respect to the nominated persons by allocating additional human resources, in particular:

- the appointment of deputies to the different nominated persons;
- the appointment of a flight safety officer for certain specific activities (EMS, lifting operations and rescue operations);
- increasing the number of people in charge of safety and conformity;
- creation of a design office whose tasks include improving documentation, operational studies and safety analyses.

5 SAFETY RECOMMENDATIONS

Note: in accordance with the provisions of Article 17.3 of Regulation No 996/2010 of the European Parliament and of the Council of 20 October 2010 on the investigation and prevention of accidents and incidents in civil aviation, a safety recommendation in no case creates a presumption of fault or liability in an accident, serious incident or incident. The recipients of safety recommendations shall report to the safety investigation authority which issued them on the measures taken or being studied for their implementation, as provided for in Article 18 of the aforementioned regulation.

Safety management for new operations

When the civil aviation authorities grant an approval for an activity, this means that, through the setting up of tailored procedures, the operator was able to demonstrate both its ability to meet the regulatory requirements (traceability, tracking, airworthiness, crew competencies, etc.), and that the procedures put in place ensure a sufficient level of safety for its operations.

However, the investigation showed that SAF HELICOPTERES had not clearly defined the operational objectives underlying its wish to obtain the specific approval for the use of hoists in commercial air transport (SPA.HHO), in particular the SPA.HHO "night" approval. The lack of precision concerning the operational context envisaged after obtaining the SPA.HHO approval raises the question as to the basis on which SAF HELICOPTERES:

- carried out the safety impact assessment for the SPA.HHO approval;
- defined the associated training and determined that the pilots in training had enough experience - in particular night flight experience - for them to follow this training.

As an example, SAF HELICOPTERES specified to the BEA during the investigation that the operational objective was to be able to finish mountain rescue operations started at the end of the day, after nightfall. There were no plans to initiate helicopter hoist operations at night. This operations restriction, which SAF HELICOPTERES indicated it wanted to impose on itself, was not clearly mentioned in the company's Operations Manual (OM). While the first flight carried out on the day of the accident at nightfall could fall into this operational framework, the second flight carried out when the night was fully established, with no moon, introduced additional difficulties which went beyond the operational framework mentioned by the instructor and by SAF HELICOPTERES.

The risk map drawn up by SAF HELICOPTERES seems to show that the safety impact assessment:

- Was not taken as an opportunity to explore the risk factors specific to both night and mountain operations.
- Focused nearly exclusively on the hoist operation phase which characterises SPA.HHO operations, without explicitly addressing the arrival at and departure phases from the mission site, which involves forward flight close to the terrain.
- Did not include a section specific to training flights undertaken as part of this SPA.HHO approval.

The risk analysis was not extended beyond the map. The expected scope of the barriers listed in this map was not specified either.

When the helicopter collided with the terrain, the hoist exercise had ended, and the pilot in training was expected to head back to the aerodrome. From this point of view, it could be considered that the accident does not correspond to a risk specific to the SPA.HHO approval. Nevertheless, the accident brought to light two risk factors specifically related to the context of the SPA.HHO training programme:

- Flight in direct proximity with the terrain, in a mountainous area and at night, in natural light conditions in which it was not possible to distinguish close obstacles, constituting an environment for which the experience of the pilot in training was probably overestimated.
- A flight which combined pilot training and hoist operator training, i.e. a context likely to increase the number of unforeseen events, the points requiring attention and the needs for coordination between the cockpit and the rear section of the helicopter.

These specific risk factors had not been anticipated by SAF HELICOPTERES in the safety impact assessment carried out to obtain the SPA.HHO approval.

In particular, the brightness of the night (light night or dark night) was not a decisional and limiting criterion for night flight in a mountainous region in immediate proximity with the terrain.

Consequently, the BEA recommends that:

- **SAF HELICOPTERES define the operational context and limits of the day and night mountain rescue flights (including or not helicopter hoist operations) in order to carry out the safety impact assessment for these operations and to determine the associated training and experience criteria.**
  [Recommendation FRAN-2022-017].

- **SAF HELICOPTERES ensure that the operational context and limits of all its flights are defined in order to carry out an appropriate risk analysis.**
  [Recommendation FRAN-2022-018].

APPENDICES

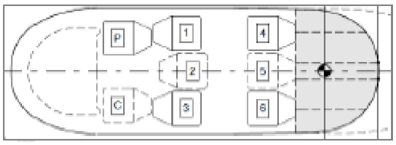
Appendix 1: Limitations

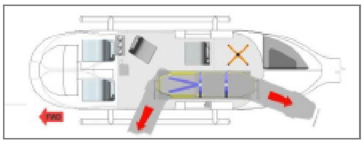
Excerpt from OM Part B QRH EC135-T1 equipped with two Arrius 2B1A_1 engines

1	Limitations	1

Limitations opérationnelles

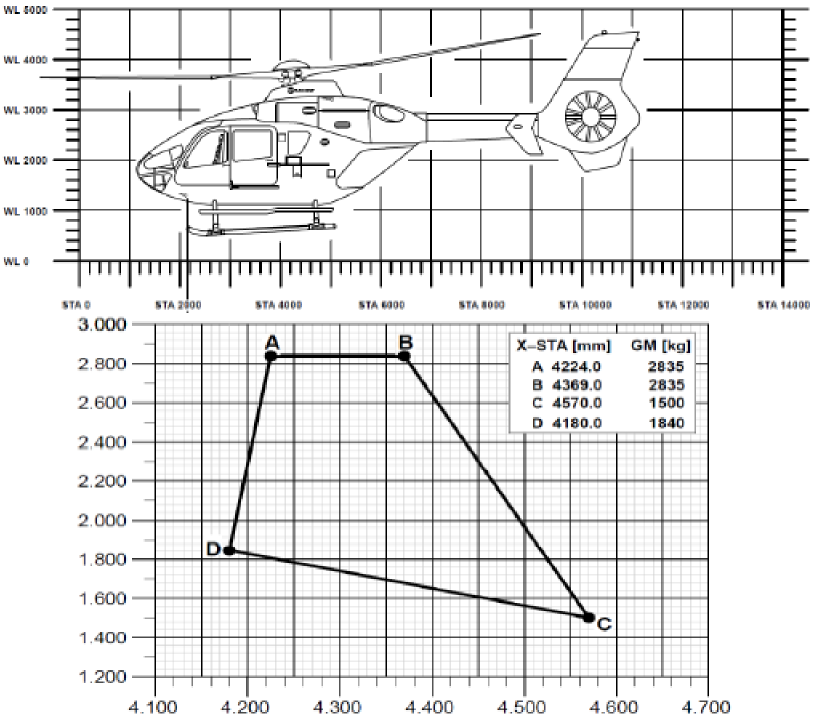
Certification : Voir EASA Type Certificate (TCDS) N° R.009 – EC 135
Configuration: 6 sièges passagers – 1 siège pilote ou sanitaire (voir schémas)





Type d'opération approuvée: **VFR jour/nuit mono pilote. Vol en condition givrante et manœuvres acrobatiques interdit.**

Limitations masse et centrage



1	Limitations	1

Limitations paramètres

Paramètres	Limitations
Masse maximale	2835 kg
Masse minimale	1500 kg
VNE	**155kt** (ou tableau VNE)
VNE OEI	**110kt** (ou tableau VNE)
VNE autorotation	**90kt** (ou tableau VNE)
Température minimale d'utilisation	- 35°C
Température maximale d'utilisation	ISA + 39°C et <50°C
Altitude maximale d'utilisation (Limitation Manuel de vol)	20 000 ft
Altitude maximale sans oxygène (Limitation transport public)	30min maximum entre 10 000ft et 13 000ft max
Vent maximal pour mise et arrêt rotor	50 kt

Limitations NR

Régimes	Avec puissance	Sans puissance
Minimal transitoire (20 s. maxi)	85 %	
Minimal continu		
1500 kg ≤ MT ≤ 1900 kg	95 %	80 %
1900 kg ≤ MT	95 %	85 %
Maximal continu	104 %	106 %
Maximal transitoire (20 s. maxi)		112 %

Limitations de pente

Limitations de pente	Avec Indication MM	Sans Indication MM
A piquer	8° maxi	6° maxi
A cabrer	12° maxi	6° maxi
En latéral	14° maxi	6° maxi

BEA

1	Limitations	1

Limitations GTM

Limitations des moteurs (Turbomeca Arius 2B1A_1)

Régime d'utilisation	Limites Transmission (Hélicoptère) Couple maxi %	Limites d'Utilisation des Moteurs		
		TOT Maxi. °C	Régime N1 Maxi/IND ∆N1 (Générateur de gaz) %	Régimes N2 Maxi. (Arbre de sortie) %
Transitoire de démarrage		895 (5 s.)		
Démarrage		810		
Transitoire			65 mini.	85mini 108 maxi.
Puissance partielle				106(≤10% TQ)
AEO				
Régime de décollage(5 mn)	V≤Vy : 2 x 75	895	-1,5	104
Régime maxi. continu	2 x 69	855	-2,4	104
OEI				
Régime 2 mn 30	128	945	+2,6	104
Régime maxi. continu	86	895	0	104

Appendix 2: Performance, weight and balance

Excerpt from OM Part B QRH EC135-T1 equipped with two Arrius 2B1A_1 engines

4 PERFORMANCES 4

CP3 : Stationnaire AEO HES

<u>Tableau n°9 :</u> Masses maximales permettant un stationnaire hors effet de sol tous moteurs en fonctionnement.

<table>
<tr><th>OAT \ Zp</th><th>0 ft</th><th>1000 ft</th><th>2000 ft</th><th>3000 ft</th><th>4000 ft</th><th>5000 ft</th><th>6000 ft</th><th>7000 ft</th><th>8000 ft</th></tr>
<tr><td>-15°C</td><td rowspan="12">2835</td><td rowspan="11">2835</td><td rowspan="11">2835</td><td rowspan="10">2835</td><td rowspan="9">2835</td><td rowspan="8">2835</td><td rowspan="7">2835</td><td rowspan="5">2835</td><td>2830</td></tr>
<tr><td>-10°C</td><td>2820</td></tr>
<tr><td>-5°C</td><td>2815</td></tr>
<tr><td>0°C</td><td>2805</td></tr>
<tr><td>5°C</td><td>2800</td></tr>
<tr><td>10°C</td><td>2825</td><td>2715</td></tr>
<tr><td>15°C</td><td>2720</td><td>2610</td></tr>
<tr><td>20°C</td><td>2730</td><td>2610</td><td>2510</td></tr>
<tr><td>25°C</td><td>2720</td><td>2625</td><td>2515</td><td>2410</td></tr>
<tr><td>30°C</td><td>2720</td><td>2620</td><td>2520</td><td>2420</td><td>2310</td></tr>
<tr><td>35°C</td><td>2720</td><td>2625</td><td>2510</td><td>2425</td><td>2325</td><td>2220</td></tr>
<tr><td>40°C</td><td>2820</td><td>2705</td><td>2600</td><td>2500</td><td>2400</td><td>2310</td><td>2225</td><td></td></tr>
</table>

Masse maximale permettant de maintenir le stationnaire HES AEO.

► Conditions :.sur 2 GTM : vent nul, prélèvement de P2 coupé, Puissance de décollage.

6 Masse et centrage 6

Voir Section 08 de la Partie A du Manuel d'Exploitation, chapitre « Masse et centrage ».

Récapitulatif des configurations

Tableau de chargement et de centrage

Configuration		Config. 1	Config. 2	Config. 3	Config. 4	Config. 5	Config. 6	Config. 7	Config. 8	Config. 9	Config. 10
Pilote		1	1	1	1	1	1	1	1	1	1
Copilote							1	1	1	1	1
Passager avant					1	1				1	1
Passager arrière			1	1	1	1		1	1	1	1
Patient				1		1			1		1
Masse de base		1986	2080	2174	2174	2268	2080	2174	2268	2268	2362
Carburant 100 kg	Masse	2174	2268	2362	2362	2456	2268	2362	2456	2456	2550
	Centrage	4425	4415	4416	4377	4379	4362	4355	4358	4321	4325
Carburant 150 kg	Masse	2224	2318	2412	2412	2506	2318	2412	2506	2506	2600
	Centrage	4413	4404	4406	4368	4370	4352	4346	4350	4313	4318
Carburant 200 kg	Masse	2274	2368	2462	2462	2556	2368	2462	2556	2556	2650
	Centrage	4403	4394	4396	4359	4362	4343	4338	4341	4306	4310
Carburant 250 kg	Masse	2324	2418	2512	2512	2606	2418	2512	2606	2606	2700
	Centrage	4392	4385	4386	4350	4353	4335	4329	4333	4298	4303
Carburant 300 kg	Masse	2374	2468	2562	2562	2656	2468	2562	2656	2656	2750
	Centrage	4383	4375	4377	4342	4345	4327	4322	4326	4291	4296
Carburant 350 kg	Masse	2424	2518	2612	2612	2706	2518	2612	2706	2706	2800
	Centrage	4381	4373	4376	4341	4344	4326	4321	4325	4291	4296
Carburant 400 kg	Masse	2474	2568	2662	2662	2756	2568	2662	2756	2756	MTOW
	Centrage	4380	4373	4375	4341	4344	4326	4321	4325	4292	MTOW
Carburant 450 kg	Masse	2524	2618	2712	2712	2806	2618	2712	2806	2806	MTOW
	Centrage	4379	4372	4375	4341	4344	4326	4322	4326	4293	MTOW
Carburant 456 kg	Masse	2530	2624	2718	2718	2812	2624	2718	2812	2812	MTOW
	Centrage	4379	4372	4375	4341	4344	4326	4322	4326	4293	MTOW

Eléments de calcul des masses de base

	Masse	Centrage
Hélicoptère vide	1750	4545
Hélicoptère en config	1901	4514
Pilote	85	2428
Matériel Sanitaire	0	-
Nourrice carburant	88	5026

	Masse	Centrage
Copilote	94	2910
Passager avant	94	2910
Passager arrière	94	3465
Patient	94	4192

Attention : le tableau récapitulatif des configurations présenté ci-dessus correspond à un hélicoptère fictif de 1901 kg en configuration, sans matériel sanitaire. **Il est donné à titre indicatif.**

La fiche de calcul permettant d'établir ce tableau à partir des masses réelles est disponible sur l'intranet du groupe.

Appendix 3: Detailed examination of engines and cockpit interfaces

1. *Généralités*

L'EC135-T1 est équipé de moteurs Arrius 2B1A1 dont le schéma de principe est représenté ci-dessous.

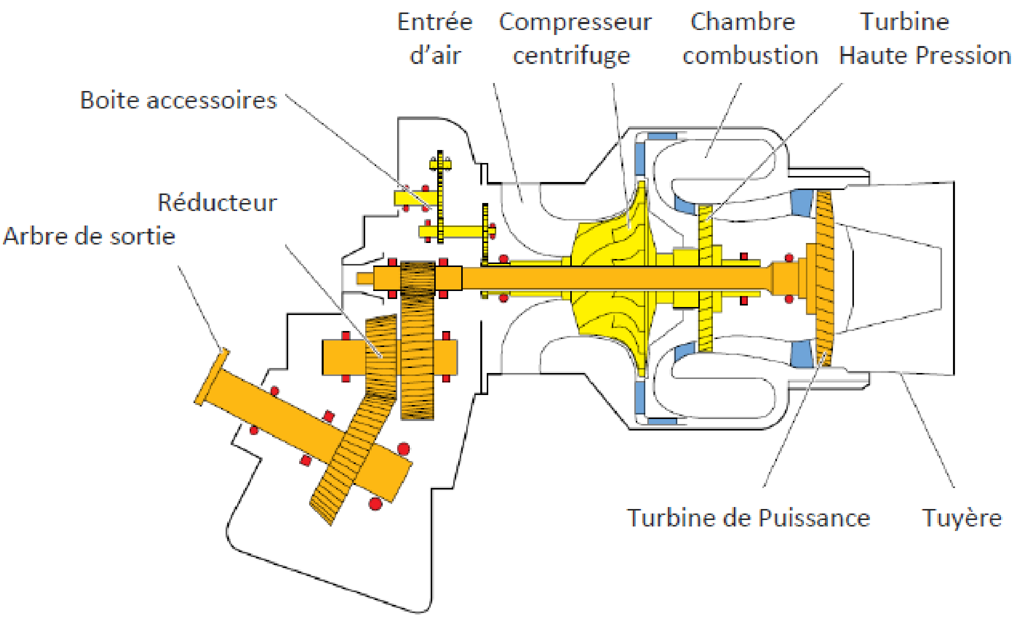


Figure 28 : détail des composants du moteur

2. *Systèmes de commande moteur dans le cockpit*

La vanne coupe-feu du moteur gauche est en position ouverte. La position de celle du moteur droit n'a pas pu être déterminée.

Les deux leviers de commande de pas collectif ont été retrouvés séparés de la cellule. La poignée tournante sur l'un des leviers est sur la position « flight », la position de la seconde poignée tournante n'a pas pu être déterminée, cette dernière étant rompue.

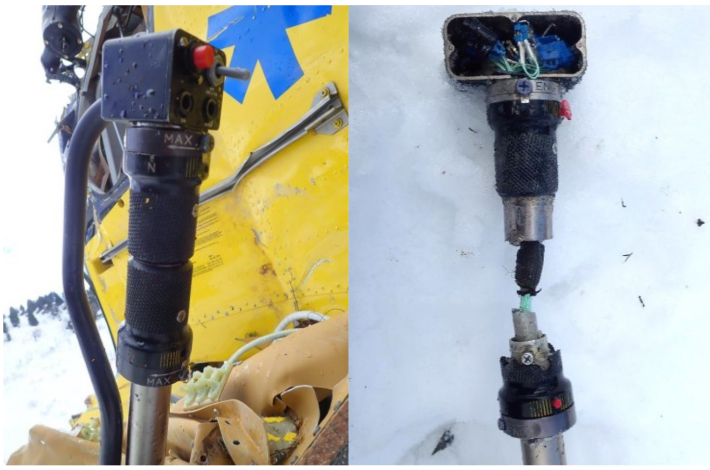


Figure 29 : poignées tournantes

La destruction du poste de pilotage et les endommagements relevés sur la console centrale supérieure n'ont pas permis de déterminer la position des différents sélecteurs et interrupteurs au moment de l'accident.

3. Capotages moteur

Le capot du moteur gauche est resté en place sur l'hélicoptère et apparait visuellement intact.
Le capot du moteur droit a été endommagé et en partie arraché, laissant le moteur partiellement exposé.
Les capotages à l'avant du compartiment BTP et incluant les entrées d'air extérieur ne sont plus présents et ont été totalement détruits.

4. Entrées d'air des moteurs

Les plénums des deux moteurs sont en place. Celui du moteur gauche est peu endommagé. Celui du moteur droit, bien que complet, est très déformé.

Figure 30 : plénums des moteurs gauche et droit

Les deux plénums ne sont pas obstrués mais contiennent de petits débris provenant de l'hélicoptère ainsi que de nombreux branchages d'arbres résineux (sapins).

Figure 31 : débris observés dans le plénum du moteur gauche

Figure 32 : débris observés dans le plénum du moteur droit

5. Circuit d'alimentation en carburant

Les supports des commandes de contrôle de débit manuel sont déformés. Le levier de la commande du moteur gauche est rompu. La position de ces commandes n'est donc représentative de la situation avant la collision avec les arbres.
Les tuyauteries souples d'alimentation en carburant des deux moteurs sont en place. Les écrous sont serrés et les fils frein sont en place. Aucune anomalie n'a été constatée.

6. Circuit d'huile

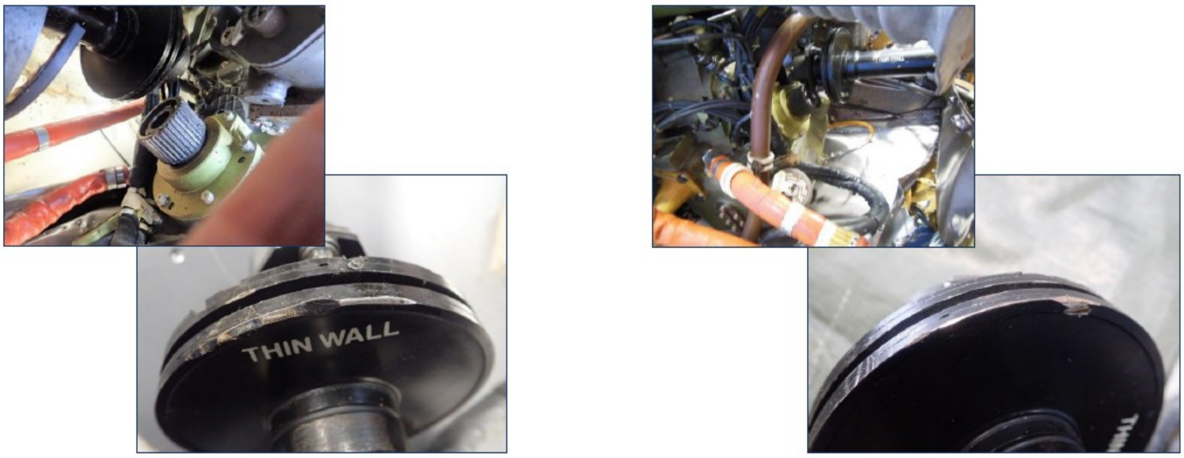
Les tuyauteries souples du circuit d'huile des deux moteurs sont en place, raccordées et ne présentent aucun endommagement. Aucune anomalie n'a été constatée.

7. Attaches moteur

Les supports du moteur gauche ne présentent pas de déformation visible. Pour le moteur droit, le support avant extérieur est rompu et le support arrière est fléchi. Ces endommagements, qui résultent de la collision avec les arbres ou le sol, ont modifié significativement le positionnement du moteur par rapport à la BTP.

8. Transmission de puissance

Les arbres de transmission de puissance entre les deux moteurs et la BTP sont connectés en entrée de la BTP mais sont désengagés des arbres cannelés en sortie des moteurs. Le désengagement des deux arbres de transmission indique un écartement important entre les deux moteurs et la BTP et sont liés à la collision avec le sol. Après leur désengagement, les arbres de transmission sont venus en contact avec les carter moteurs et avec les arbres cannelés de sortie de puissance moteur. Les traces de frottements sur les arbres de transmission de puissance sont de faible amplitude (secteur angulaire) ce qui indique une absence de rotation de ces derniers.



Moteur gauche Moteur droit

Figure 33 : Position des arbres de transmission et traces d'interférence

9. Prolongateur de tuyère

Le prolongateur du moteur gauche est en place et présente de légères déformations à son extrémité. Le prolongateur de tuyère du moteur droit est en place mais très endommagé (écrasement).

10. Examen détaillé du moteur n° 1 (gauche) s/n 30206

Le moteur ne présente pas de dommage significatif visible.

Figure 34 : vue d'ensemble du moteur gauche

10.1 Module 1

Le module 1 était en bonne condition générale.
Après la dépose du démarreur de la boîte accessoire, la rotation manuelle de l'arbre a entraîné la rotation du générateur de gaz a permis de vérifier la continuité de la chaine cinématique complète du moteur. Aucun point dur ou bruit anormal n'a été décelé lors de cet essai.
La rotation manuelle de l'arbre de sortie de puissance du moteur a entraîné la rotation de la turbine de puissance sans point dur ni bruit anormal, confirmant la continuité de la chaine cinématique de puissance.
Le flasque situé entre le carter et l'arbre de sortie cannelé a reçu plusieurs impacts. La position de ces impacts est en cohérence avec la position de l'arbre de transmission de puissance qui a été constatée sur l'épave.
Les cannelures de l'arbre de sortie montrent de traces de contacts de faible profondeur et de faible

largeur formant des trajectoires hélicoïdales, ce qui indique que l'arbre de sortie moteur tournait lors du désaccouplement de l'arbre de transmission. L'absence d'arrachement de matière en extrémité des cannelures indique un faible couple lors du désaccouplement.

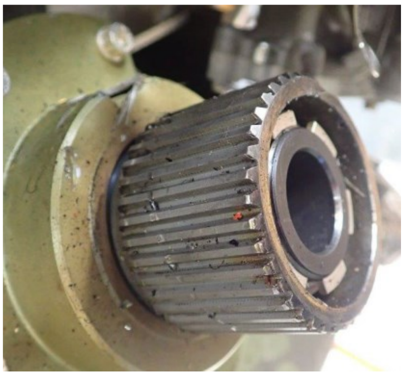


Figure 35 : arbre cannelé et flasque

L'ensemble de ces observations indique que le moteur et la BTP se sont, dans un premier temps, écartés avant de se rapprocher.

10.2. Module 2

Le module 2 est en bonne condition.

Les pales du compresseur et les aubes du diffuseur centrifuge sont en bon état, sans dommage apparent, ni érosion. De nombreux débris de petite taille sont présents et en cohérence avec les débris observés dans le plénum. Une légère trace de touche est observée en sommet de pale du rouet. Il n'est pas possible de déterminer si cette touche résulte de l'accident ou si elle était antérieure. Toutefois, cette trace de touche est superficielle et n'a pas d'incidence sur le fonctionnement du compresseur.

L'examen endoscopique de la chambre de combustion, de la turbine haute pression et de la turbine de puissance a montré que ces organes sont propres et en bon état. De légère traces de contact rotor/stator ont été décelées sur la turbine de puissance. La nature de ces traces de contact n'a pas affecté le fonctionnement de cette dernière.

11. Équipements

La grille d'entrée d'air est en place et en bon état. De nombreux débris de petite taille sont incrustés dans la grille et en cohérence avec la nature des débris retrouvés dans le plénum.

L'ensemble des tuyauteries et des faisceaux électriques sont en place et en bon état. Les raccords des tuyauteries sont serrés et les connecteurs des faisceaux sont connectés et serrés.

La tuyère est en place et en bon état.

Le filtre à carburant et son réceptacle sont propres, aucune trace de carburant n'est visible, l'indicateur de colmatage n'est pas apparent.

Le filtre à huile et son réceptacle sont propres, de l'huile est présente dans le réceptacle, l'indicateur de colmatage n'est pas apparent.

Les deux bouchons magnétiques ne présentent pas de particule ou de dépôt significatif.

Le HMU est en place et ne présente aucune anomalie. L'ensemble des tuyauteries et faisceaux sont correctement raccordés.

L'ensemble clapet et sa protection sont en place et ne présentent aucun dommage.

12. Examen détaillé du moteur n° 2 (droit) s/n 30045

Le moteur présente plusieurs dommages significatifs au niveau des équipements externes.

Figure 36 : vue d'ensemble du moteur gauche

13. Module 1

Le module 1 était en bonne condition générale.
Après la dépose du démarreur de la boîte accessoire, la rotation manuelle de l'arbre a entraîné la rotation du générateur de gaz a permis de vérifier la continuité de la chaine cinématique complète du moteur. Aucun point dur anormal n'a été décelé lors de cet essai, seul un faible bruit typique d'un léger frottement a été détecté.
La rotation manuelle de l'arbre de sortie de puissance du moteur a entraîné la rotation de la turbine de puissance sans point dur ni bruit anormal, confirmant la continuité de la chaine cinématique de puissance.
Le flasque situé entre le carter et l'arbre de sortie cannelé a reçu un impact en partie supérieure. La position de cet impact est en cohérence avec la position de l'arbre de transmission de puissance qui a été constatée sur l'épave. Les cannelures de l'arbre de sortie montrent deux traces de contacts de faible profondeur et de faible largeur formant des trajectoires hélicoïdales, ce qui indique que l'arbre de sortie moteur tournait lors du désaccouplement de l'arbre de transmission. L'absence d'arrachement de matière en extrémité des cannelures indique un faible couple lors du désaccouplement.

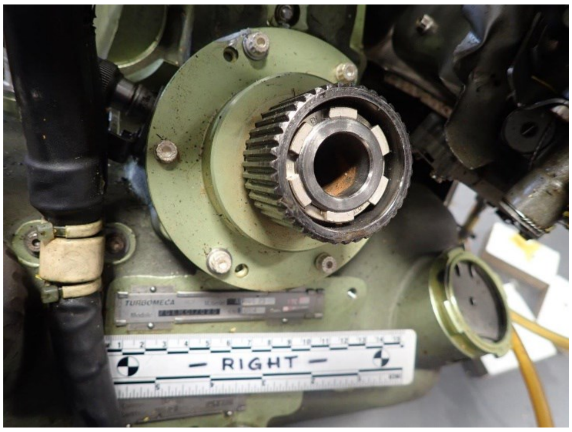


Figure 37 : arbre cannelé et flasque

L'ensemble de ces observations indique que le moteur et la BTP se sont, dans un premier temps, écartés avant de se rapprocher.

14. Module 2

Le module 2 est en bonne condition.
Les pales du compresseur et les aubes du diffuseur centrifuge sont en bon état, sans dommage apparent, ni érosion. De nombreux débris de petite taille sont présents et en cohérence avec les débris observés dans le plénum. Une légère trace de touche est observée en sommet de pale du rouet. Il n'est pas possible de déterminer si cette touche résulte de l'accident ou si elle était antérieure. Toutefois, cette trace de touche est superficielle et n'a pas d'incidence sur le fonctionnement du compresseur.
L'examen endoscopique de la chambre de combustion, de la turbine haute pression et de la turbine de puissance a montré que ces organes sont propres et en bon état. Des traces de contact rotor/stator ont été décelées sur la turbine de puissance. La nature de ces traces de contact n'a pas affecté le fonctionnement de cette dernière.

15. Équipements

La grille d'entrée d'air est en place et en bon état. De nombreux débris de petite taille sont incrustés dans la grille et en cohérence avec la nature des débris retrouvés dans le plénum.
Quelques débris fibreux sont plaqués à l'intérieur de la grille à des endroits qui ne correspondent ni au point bas lorsque l'hélicoptère est sur ses patins, ni au point bas correspondant à la position de l'épave sur le site. Cette observation peut indiquer un souffle de l'intérieur du moteur vers l'extérieur résultant d'un pompage moteur après l'ingestion de débris.

L'ensemble des tuyauteries sont en place et leurs raccords sont connectés et serrés. Néanmoins plusieurs d'entre elles sont déformées ou localement écrasées.

La plupart des faisceaux électriques sont en place et les connecteurs des faisceaux sont connectés et serrés. Seuls les connecteurs du boitier de raccordement des faisceaux du harnais pyrométrique sont arrachés. Ce boitier est situé à proximité des tuyauteries ayant été endommagées.

La tuyère est en place mais fortement endommagée très probablement par le contact avec le sol.

Le filtre à carburant et son réceptacle sont propres, aucune trace de carburant n'est visible, l'indicateur de colmatage n'est pas apparent.

Le filtre à huile et son réceptacle sont propres, de l'huile est présente dans le réceptacle, l'indicateur de colmatage n'est pas apparent.
Les deux bouchons magnétiques ne présentent pas de particule ou de dépôt significatif.

Le HMU est en place et ne présente aucune anomalie. L'ensemble des tuyauteries et faisceaux sont correctement raccordés.
L'ensemble clapet et sa protection sont en place. La plaque de protection est enfoncée et de la matière végétale a été retrouvée à proximité.

Appendix 4: Examination of computers

1. ECU

L'ECU (Engine Control Unit) est un calculateur numérique assurant la régulation du débit carburant et la gestion des paramètres moteur. Des informations de pannes et leur contexte sont enregistrés dans une mémoire non volatile à des fins d'aide à la maintenance.

2. Généralité sur les données enregistrées par les calculateurs

Dès que le calculateur est alimenté deux compteurs sont incrémentés :

- *compteur de temps total de fonctionnement « Total time » depuis la sortie d'usine ;*
- *compteur de temps de mise sous tension « Power On time » depuis le démarrage du vol.*

Ce dernier repart de zéro à chaque mise sous tension.

Le calculateur déclenche l'enregistrement d'un bloc de « contexte de panne » lorsqu'une panne moteur ou calculateur est détectée. Il enregistre alors les paramètres moteur principaux, les états des entrées et sorties logiques, le mode de régulation et les messages de pannes. Jusqu'à huit blocs de « contexte de pannes » peuvent être enregistrés.
Les blocs associés au vol de l'événement ont pu être identifiés grâce aux valeurs des compteurs.

Les données enregistrées dans les blocs de données sont les suivantes :

Désignation	*Unité de mesure*
N1 : Vitesse du générateur de gaz	*% (100 % = 54 117 tr/min)*
N2 : Vitesse de la turbine libre	*% (100 % = 44 038 tr/min)*
P0 : Pression atmosphérique	*mBar*
P3 : Pression de la chambre à combustion	*Bar*
T1 : Température de l'air ambiant	*°C*
T4 : Température en sortie de la turbine haute pression	*°C*
Pas du collectif	*%*
Couple	*% (100 % = 665 Nm)*
Valeur de consigne N1	*%*
Valeur de consigne débit carburant	*l/hr*
Entrées logiques	
Sorties logiques	
Occurrence (type de panne)	

3. Données enregistrées

Les calculateurs étaient dans un état permettant leur remise sous tension. Ils ont été connectés sur banc et les données ont été déchargées.

Calculateur n°1 (s/n 6ALD0133CE)

Le bloc n°3 correspondait au vol de l'accident. Pour ce bloc, le « total time » était de 1 786,5 h et le « power on time » de 54 min 34.

Calculateur n°2 (s/n 6ALD0116CE)

Le bloc n°1 correspondait au vol de l'accident. Pour ce bloc, le « total time » était de 7 053,3 h et le « power on time » de 54 min 33.

Synthèse des données enregistrées

Le tableau ci-dessous résume les données enregistrées dans le bloc n°3 du calculateur du moteur gauche et celles du bloc n°1 du calculateur du moteur droit :

Désignation	*Calculateur n°1 (moteur gauche), bloc n°3*	*Calculateur n°2 (moteur droit), bloc n°1*
Temps total de fonctionnement	*1 786,5 h*	*7 053,3 h*
Temps depuis dernière mise sous tension	*54 min 34*	*54 min 33*
N1	*92,5 %*	*93,9 %*
N2	*99,1 %*	*98,2 %*
P0	*807 mbar*	*805 mbar*
P3	*5,81 Bar*	*6,00 Bar*
T1	*4,4 °C*	*1,4 °C*
T4	*722,8 °C*	*728,8 °C*
Collective pitch	*61,6 %*	*56,2 %*
Couple	*39,6 %*	*42,0 %*
Consigne N1	*105 %*	*98,7 %*
Consigne débit carburant	*146,3 l/hr*	*150,3 l/hr*
Entrées logiques	*Vol*	*Vol*
Sorties logiques	*Mode régulation dégradé*	*Mode régulation dégradé*
Occurrence	*Panne Pas Collectif (externe)*	*Panne Pas Collectif (externe)*

4. Exploitation des données

Les deux calculateurs ont enregistré quasi simultanément l'occurrence « Panne Pas Collectif ». Ce message indique la détection d'une valeur invalide dans la chaîne de mesure de recopie de la position du Pas Collectif. Le calculateur déclare le signal invalide lorsque :

- *la valeur est hors limites (inférieure à 7 % ou supérieure à 93 %) ;*
- *la variation de la valeur dépasse un gradient de 200 %/sec.*

À la suite de cette occurrence, la valeur du signal du « Pas Collectif » n'est plus prise en compte par le système de régulation et est remplacée par une valeur de recueil. Le système de régulation envoie également un signal au système avionique qui indique alors le message « DEGRADE » synonyme de fonctionnement du système de régulation en mode automatique dégradé lié à l'utilisation de la valeur de recueil. Le système de régulation continue de contrôler le moteur en mode automatique.

Les paramètres du moteur n°1 montrent que ce dernier fonctionnait à 92,5 % de N1, soit 50 058 tr/mn, que la température des gaz en sortie de turbine haute pression était de T4=772,8 °C et que le moteur délivrait 39,6 % de couple soit 263 Nm. La vitesse de la Turbine Libre était de 99,1 %, soit 43 642 tr/mn. La valeur en N1 était inférieure à la limite de 54 009 tr/mn dans les conditions de vol relevées par le calculateur. Les valeurs en T4 et couple étaient inférieures aux limites acceptables par le moteur à la PMC de 855 °C et 75,1 % respectivement. La vitesse N2 était dans la plage d'utilisation autorisée sans limite de durée en vol de 94 % < N2 < 106 %.

Les paramètres du moteur n°2 montrent que ce dernier fonctionnait à 93,9 % de N1, soit 50 816 tr/mn, que la température des gaz en sortie de turbine haute pression était de T4=728,8°C et que le moteur délivrait 42 % de couple soit 279 Nm. La vitesse de la Turbine Libre était de 98,2 %, soit 43 245 tr/mn. La valeur en N1 était inférieure à la limite de 54 009 tr/mn dans les conditions de vol relevées par le calculateur. Les valeurs en T4 et couple étaient inférieures aux limites acceptables par le moteur à la

PMC de 855 °C et 75,1 % respectivement. La vitesse N2 était dans la plage d'utilisation autorisée sans limite de durée en vol de 94 % < N2 < 106 %.

Ces données indiquent ainsi que, lors de l'enregistrement des occurrences « Panne Pas collectif », les moteurs délivraient de la puissance, qu'ils étaient dans un mode de régulation cohérent avec des conditions de vol (mode de régulation automatique et position « Vol ») en mode dégradé provenant de la « Panne Pas Collectif » et qu'ils n'avaient atteint aucune des limites.

5. Positionnement de la panne dans la séquence de l'accident

En générant une panne artificielle, il a été possible de déterminer la temporalité de la perte d'alimentation des calculateurs :

entre 0 et 1 minute après l'enregistrement du bloc 3 sur le calculateur n°1 ;
entre 0 et 3 minutes après l'enregistrement du bloc 1 sur le calculateur n°2.

Chaque calculateur est alimenté par l'alternateur du moteur associé et par le réseau de bord 28 V de la batterie.

6. DTS

Calculateur GNSS qui transmet les positions de l'aéronef à la station sol à un échantillonnage d'un point par minute. Si une carte SD est insérée en façade, les positions sont enregistrées toutes les secondes. Le DTS peut également être connecté au Brite Saver, dans ce cas les positions sont enregistrées dans le Brite Saver toutes les secondes si la liaison d'échange de données entre le DTS et le Brite Saver a été activée[40] dans le fichier de configuration du Brite Saver.
Le DTS ne contient pas de mémoire interne enregistrant les paramètres de position. Aucune donnée n'a été récupérée.

7. Carte SD du DTS

Sur la carte SD retrouvée dans l'épave, 102 fichiers de données de vol étaient présents, ainsi que 102 fichiers de journaux d'événement associés. Les plus récents dataient du 05/07/2014. Au vu des données enregistrées, la carte SD n'était probablement pas insérée dans le boîtier DTS lors du vol de l'événement.

Aucune donnée relative au vol de l'événement n'a été récupérée.

8. Carte SD insérée en façade du Brite Saver

Le Brite Saver est un calculateur qui enregistre des paramètres moteurs et des paramètres de vol à des fins d'aide à la maintenance. Les données du Brite Saver sont enregistrées dans une carte SD insérée en façade et dans une mémoire interne au calculateur. Les données sont transférées sur une mémoire tampon avant d'être écrites par paquets représentant environ 8 secondes de vol sur la carte SD et la mémoire interne. En cas d'arrêt brutal du calculateur, jusqu'à 8 secondes de données peuvent être perdues.

Les données présentes sur la carte SD ont été extraites et décodées.

Pour la journée du 8 décembre 2020, 18 mises sous tension (MST) étaient enregistrées. Les paramètres suivants étaient enregistrés toutes les secondes :

[40] Activation logicielle.

Paramètre	*Unité*	*Commentaire*
Date/heure	*hh:mm:ss*	*Temps du Brite Saver*[41]
NG 1 et NG 2	*%*	*Vitesse du générateur de gaz (moteur 1 ou 2)*
NF 1 et NF 2	*%*	*Vitesse de la turbine libre (moteur 1 ou 2)*
NR	*%*	*Vitesse du rotor principal*
T4 1 et T4 2	*°C*	*Température à la sortie de la chambre de combustion (moteur 1 ou 2)*
Couple 1 et Couple 2	*%*	*Couple du moteur 1 et du moteur 2*
Température extérieure	*°C*	*-*
Température compensation	*°C*	*Non utilisée*
ZP	*ft*	*Altitude pression - non enregistrée*[42]
Température d'huile 1 et Température d'huile 2	*°C*	*Température d'huile du moteur 1 et du moteur 2*
Température interne	*°C*	*Température interne du calculateur*
Tension	*V*	*Tension de la batterie*
Contact patin[43]	*booléen*	*1 = contact avec le sol* *0 = pas de contact*

L'examen des données archivées du Brite Saver montre que la liaison avec le DTS était activée jusqu'au 2 juin 2019 et les données GNSS étaient enregistrées par le Brite Saver. À partir du 3 juin 2019, les données GNSS n'apparaissent plus dans les données enregistrées du Brite Saver. L'origine de ce changement n'a pas pu être déterminée.

Sur les 18 MST, 5 correspondaient à des vols :

Numéro de vol	***Heures de mise sous tension/hors tension***	***Heures de décollage et d'atterrissage***
1	*07 h 22 min 11* *08 h 50 min 30*	*07 h 31 min 13* *08 h 47 min 58*
2	*09 h 10 min 06* *09 h 45 min 10*	*09 h 15 min 16* *09 h 42 min 58*
3	*10 h 13 min 35* *11 h 08 min 37*	*10 h 22 min 37* *11 h 06 min 27*
4	*12 h 34 min 41* *13 h 28 min 16*	*12 h 39 min 18* *13 h 24 min 49*
5	*13 h 52 min 52* *14 h 45 min 29*	*13 h 57 min 00* *14 h 43 min 07*

[41] La date et l'heure ne sont pas automatiquement recalées par le calculateur car il ne dispose pas de source de temps pour le faire. La date et l'heure sont préconfigurées en usine et doivent être ajustées si nécessaire lors de l'installation puis contrôlées régulièrement. Compte tenu des différents éléments recueillis par ailleurs, l'heure du Brite Saver présente un décalage sur l'heure UTC qui a été estimé approximativement à 28 min 20 (en retard sur l'heure UTC).

[42] L'altitude pression (paramètre ZP) n'était pas enregistrée. Ce paramètre provient normalement d'un capteur de pression inclus dans le kit de montage du Brite Saver.

[43] L'état air/sol est déterminé par un switch mécanique ou ultrason sous le fuselage. Le switch est le moyen primaire de détection de décollage ou atterrissage. Il est doublé par une logique de vol en cas de dysfonctionnement du patin (conditions sur le couple et le régime NR).

Les deux vols de nuit (vol de l'accident et vol précédent avec changement d'équipage rotor tournant) n'ont pas été enregistrés sur la carte SD. Il s'agit d'un problème connu par le constructeur, probablement dû à une désynchronisation entre la carte SD et le calculateur. Un voyant en façade s'allume alors et l'équipage doit appuyer sur le bouton de synchronisation pour relancer l'enregistrement et récupérer les données manquantes. Ces données sont enregistrées en interne du calculateur même en cas de désynchronisation.

9. Brite Saver

Compte tenu de l'absence de données relatives aux deux vols de nuit sur la carte SD insérée en façade, la mémoire interne du Brite Saver a été débrasée, testée électriquement et lue. Le fichier binaire de données a été extrait.

Les paramètres enregistrés sont identiques à ceux qui sont enregistrés sur la carte SD. Une mise sous tension supplémentaire était enregistrée dans la mémoire interne. Le décodage des paramètres a été validé par comparaison avec les vols précédents enregistrés sur la carte SD.

10. Warning Unit

Le WU est un panneau d'alarmes qui annonce des situations d'urgence par l'intermédiaire d'alarmes sonores et lumineuses. Une mémoire interne enregistre les 31 derniers changements d'état d'apparition/disparation des alarmes. Ces événements ne sont pas datés. L'enregistrement est uniquement utilisé en cas de microcoupure d'alimentation pour régénérer l'alarme au rallumage.

Le calculateur était endommagé. Le composant mémoire a été débrasé, testé électriquement et lu. Il n'y avait aucune donnée.

11. Cockpit Display Unit

Le CDU est un calculateur qui affiche les principaux paramètres moteur, carburant et électriques, ainsi que des alertes de type CAUTION. Les codes d'erreur des ECU et les alertes déclenchées durant les 60 dernières secondes sont enregistrés dans une mémoire interne non volatile.

Le calculateur était endommagé. Le boîtier présentait des déformations et le bouton rotatif de sélection des modes était cassé. Le boîtier a été ouvert pour vérifier l'état des cartes électroniques et vérifier l'absence de court-circuit. Le bouton rotatif a été remplacé. Le calculateur a été mis sous tension en mode maintenance. L'écran du haut s'est révélé cassé. Un condensateur a brûlé. Compte tenu des données récupérées par ailleurs, aucun examen complémentaire n'a été effectué sur ce calculateur.

Appendix 5: SPA.HHO “Initial” pilot flight session sheets

SEANCE VOL HHO N°1 *	TEMPS DE FORMATION	FORMATEUR
• Mise en place treuillage • Treuillage d’une charge à différentes hauteurs en espace suffisamment dégagé des obstacles. • Treuillage d’une charge en espace confiné. • Coordination équipage	1h00/ 6 treuillages	Désigné RDFE

SEANCE VOL HHO N°2 *	TEMPS DE FORMATION	FORMATEUR

• Procédures d’urgence :
  o Panne Génératrice
  o Panne moteur treuil
  o Panne GTM
  o Perte de communication
  o Coordination équipage
	1h00/
	6 treuillages
		Désigné RDFE

SEANCE VOL HHO N°3	TEMPS DE FORMATION	FORMATEUR
• Treuillage 1 et 2 personnels d’intervention • Treuillage civière • Coordination équipage	1h00/ 6 treuillages	Désigné RDFE

SEANCE VOL HHO N°4	TEMPS DE FORMATION	FORMATEUR

• Contrôle en vol
  o Choix site treuillage
  o Mise en place
  o Reconnaissance
  o Procédures normales et d’urgence
  o Coordination équipage
	0h40	Désigné RDFE

BEA

Appendix 6: SPA.HHO "Advanced mountain" and "Advanced night" flight programme

SEANCE VOL HHO AV MONT n°1	TEMPS DE FORMATION	FORMATEUR
• Treuillage avec repères fiables • Trajectoires de sécurité. • Trajectoires de dégagement.	1h00/ 6 treuillages	Désigné RDFE

SEANCE VOL HHO AV MONT n°2	TEMPS DE FORMATION	FORMATEUR
• Treuillage avec repères complexes. • Treuillage grande hauteur	1h00/ 6 treuillages	Désigné RDFE

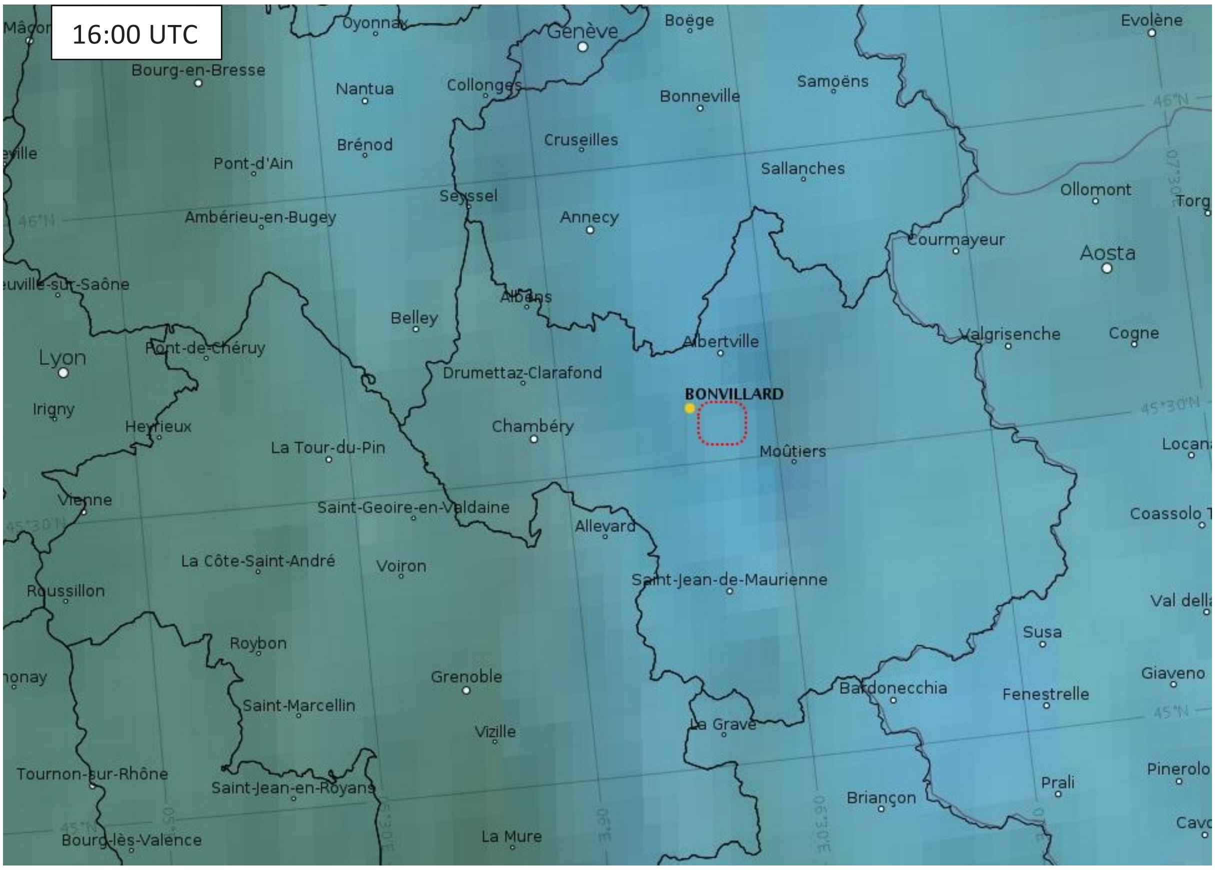
SEANCE VOL HHO AV MONT n°3	TEMPS DE FORMATION	FORMATEUR
• Treuillage poulie traction • Treuillage lézard	1h00/ 6 treuillages	Désigné RDFE

SEANCE VOL HHO AV NUIT n°1	TEMPS DE FORMATION	FORMATEUR
• Treuillage avec repères fiables • Trajectoires de sécurité. • Trajectoires de dégagement.	1h00/ 6 treuillages	Désigné RDFE

SEANCE VOL HHO AV NUIT n°2	TEMPS DE FORMATION	FORMATEUR
• Treuillage avec repères complexes. • Trajectoires de sécurité. • Trajectoires de dégagement.	1h00/ 6 treuillages	Désigné RDFE

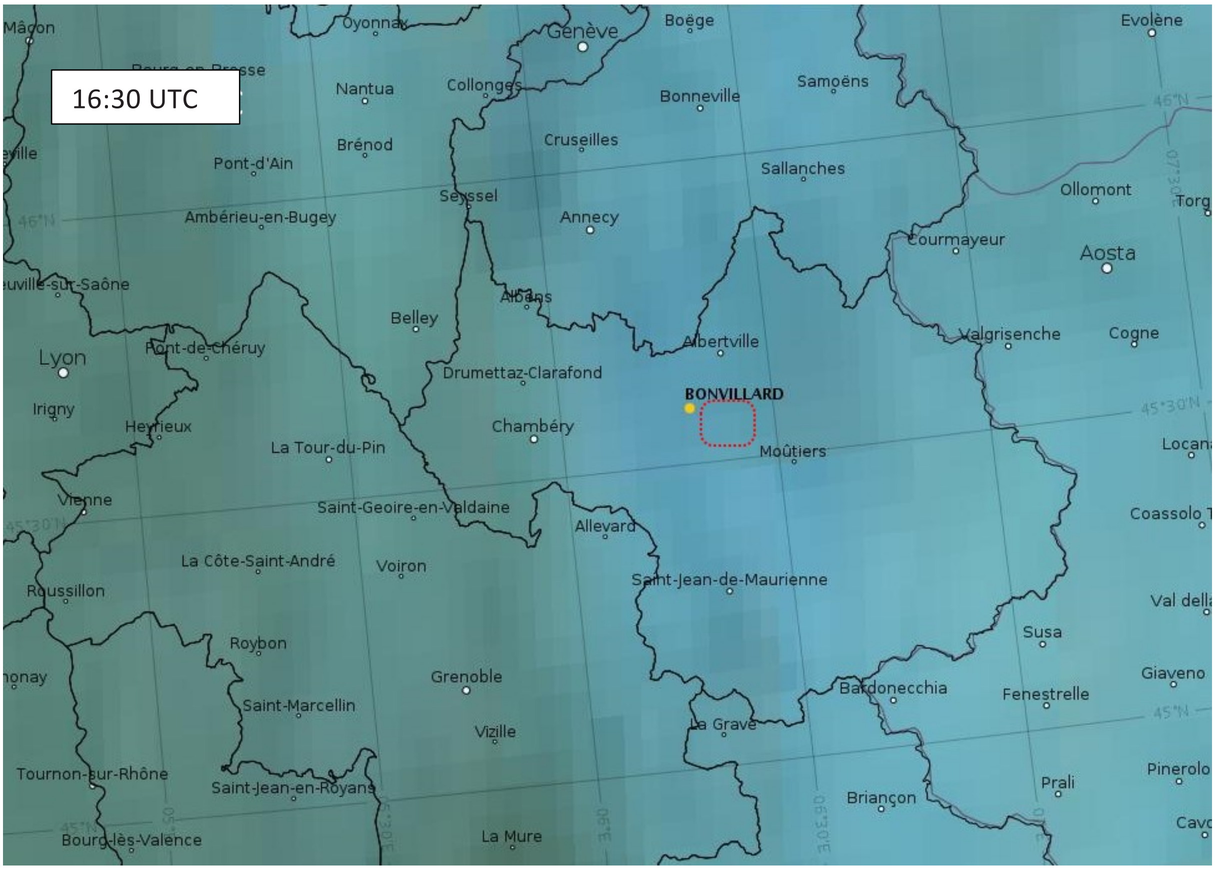
Appendix 7: Satellite charts from 16:00 to 17:30

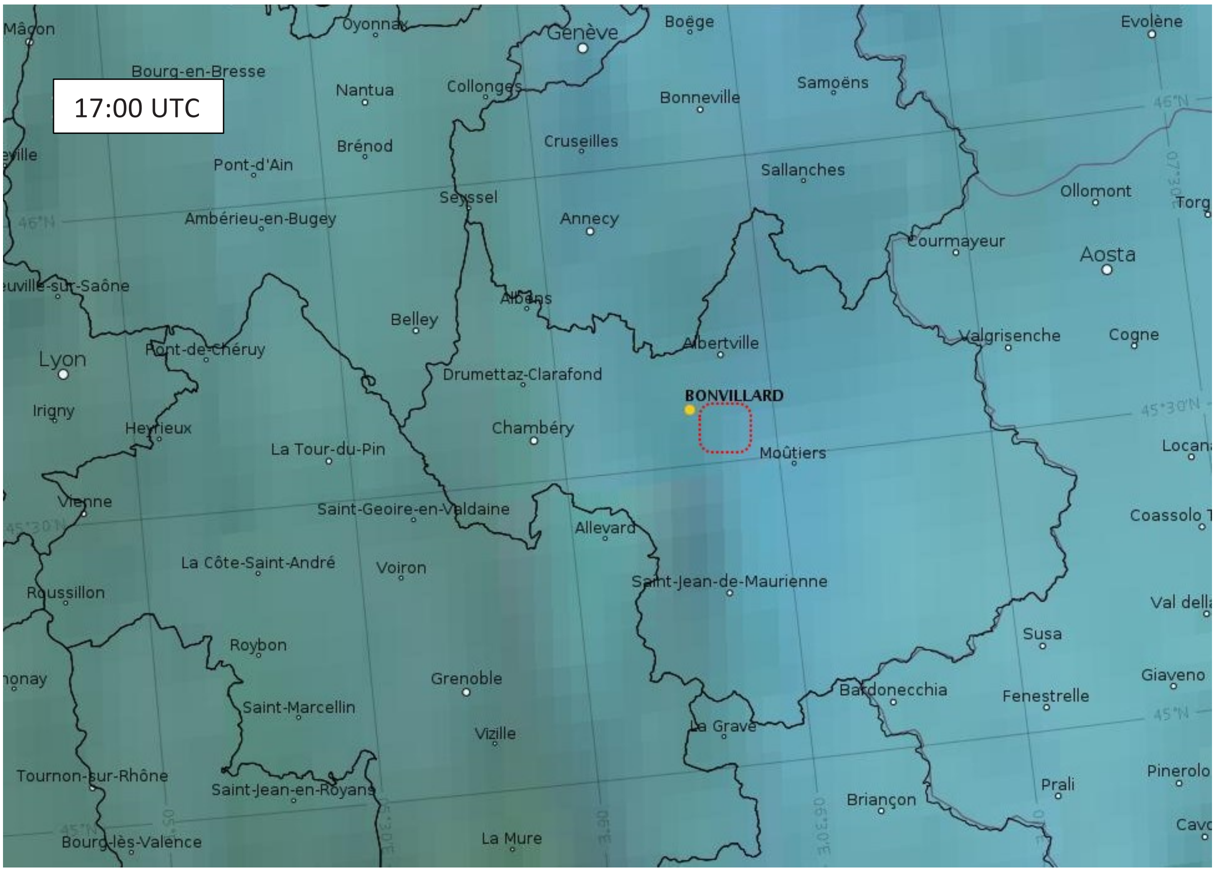
The colour satellite images recorded over the period of the accident flight and the previous night flight are presented below.

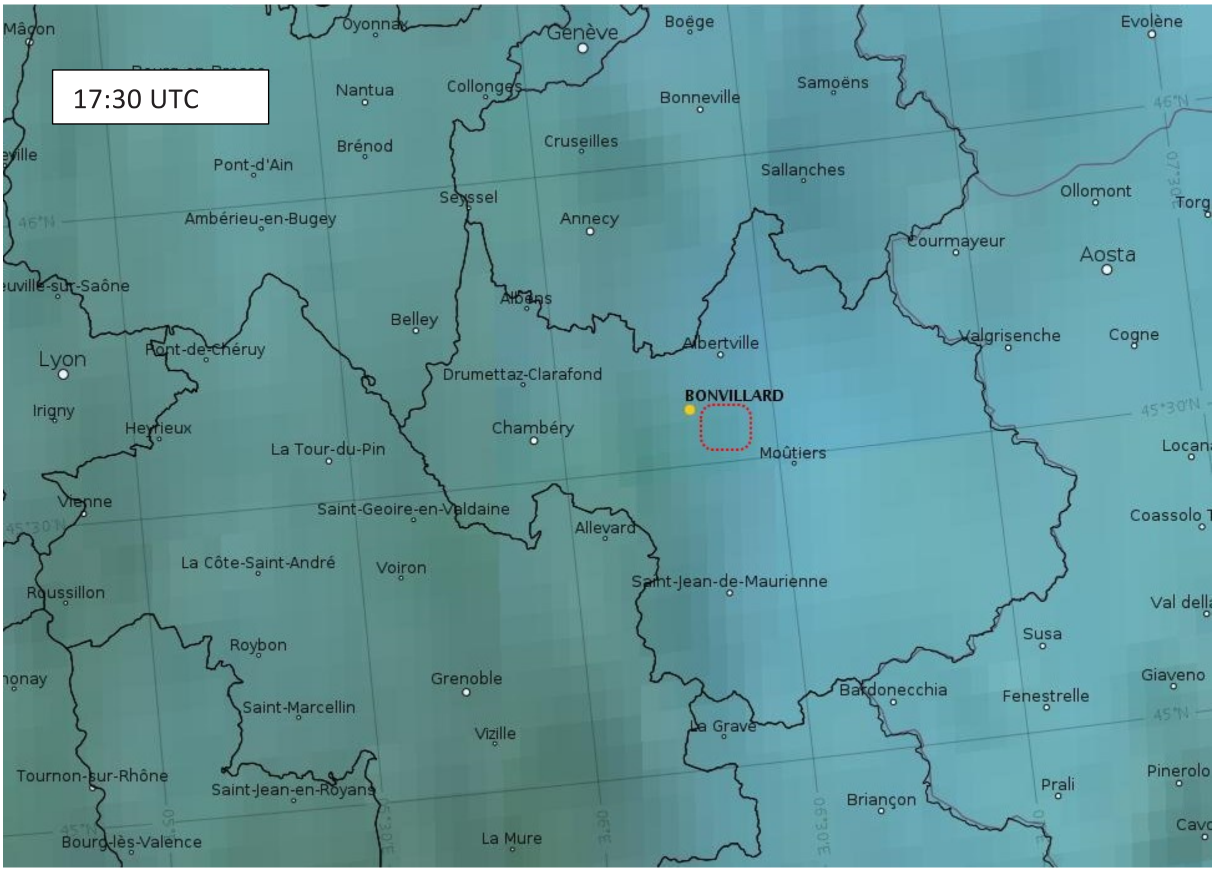


Colour imaging allows the information obtained from various measurements to be combined.

- Low-level stratus or stratocumulus clouds are shown in various shades of yellow depending on their altitude (yellow: low altitude, pale yellow: higher altitude).
- Thin, high-level cirrus clouds, consisting only of ice particles, are shown in light-blue tones.
- White is indicative of clouds with high density or thickness, which characterise disturbance or cumulonimbus clouds.
- The land colours alternate from greenish brown for vegetated soils to yellow ochre for desert areas. Snow and ice are very white, a sign of their strong reflectivity.
- Some very low-level stratus clouds are invisible on the image because their temperature is close to that of the surface.


16:30 UTC
BONVILLARD
Genève
Annecy
Chambéry
Grenoble
Lyon
Albertville
Moûtiers
Saint-Jean-de-Maurienne
Aosta
Briançon


17:00 UTC
BONVILLARD
Genève
Annecy
Chambéry
Grenoble
Lyon
Albertville
Moûtiers
Saint-Jean-de-Maurienne
Aosta
Briançon


17:30 UTC
BONVILLARD
Genève
Annecy
Chambéry
Albertville
Moûtiers
Saint-Jean-de-Maurienne
Grenoble
Lyon
Aosta
Courmayeur
Briançon
Bardonecchia
Susa

Appendix 8: SPA.HHO training (Part TCM)

1. Selection levels and criteria

This training is designed to lead to the acquisition of one of the two levels of HHO operations.

2. "Initial HHO" qualification

"Un assistant de vol qualifié « stade initial HHO » est en mesure de réaliser des opérations de treuillage en plaine, où des repères visuels fiables sont à proximité immédiate, et où des obstacles ou des mouvements de terrain particuliers interdisent un posé. Cette formation est générique et peut être mise en œuvre quel que soit le treuil utilisé dès lors que le module théorique n°1 est suivi."

Prerequisites

"L'assistant de vol postulant pour une formation HHO doit être qualifié assistant de vol et posséder une expérience minimale de 2 ans dans une fonction d'assistant de vol et/ou de spécialiste de tâche SPO.
Par la suite, afin d'opérer en opération réelle en tant qu'opérateur HHO, une expérience minimale de 50 treuillages est exigée."

Recognition of experience

"S'agissant des assistants de vol possédant déjà une expérience avérée dans le domaine de l'hélitreuillage acquise au sein de SAF HELICOPTERES (HEC), des armées ou d'une autre compagnie, une évaluation sera réalisée par le RDFE ou un pilote désigné, ainsi qu'un assistant de vol, désigné par le RDFE « instructeur HHO ». A l'issue de cette évaluation et selon les critères précisés ci-dessous, le RDFE pourra réduire la formation afin d'adapter leurs connaissances aux procédures pratiquées par SAF HELICOPTÈRES et à l'équipement qu'ils serviront. A minima, le module théorique n°5, un vol « procédures HHO » et un vol « procédures d'urgence » seront réalisés.

Critères pris en compte pour mener une formation réduite :
- *Niveau de l'évaluation ;*
- *Expérience minimale d'assistant de vol ou équivalent de 2 ans ;*
- *Expérience globale minimale en treuillage de 50 treuillages ;*
- *Expérience avec un équipement similaire à celui exploité ;*
- *Environnement géographique dans lequel le candidat a développé son expérience treuillage (exemple : France, Canada, Afrique, etc.) ;*
- *Expérience récente du candidat."*

Content of the assessment

"Celle-ci est composée du test de fin de formation théorique HHO ainsi que certains items du contrôle de fin de formation pratique HHO (cf. Check Forms).
A l'issue de ces deux tests, le RDFE adaptera la formation afin de présenter le postulant au test de fin de formation HHO (cf Check Forms)."

Training

"Cette formation comprend une partie théorique et une composante pratique."

3. "Advanced HHO" qualification

"Un TCM qualifié « stade avancé HHO », peut effectuer tout type d'intervention SMUH à l'aide du treuil en milieu montagneux et/ou mer, mais aussi de nuit, dès lors qu'il aura suivi la formation avancée correspondante.
SAF HELICOPTERES considère que cette formation complète la formation et l'expérience du pilote quant au milieu considéré."

Prerequisites

"Les critères afin de prétendre à l'obtention de la qualification « Stade avancé HHO » sont les suivants : Le TCM doit justifier d'un minimum de 50 treuillages."

Recognition of experience

"Le RDFE doit prendre en compte l'expérience globale du candidat selon les critères suivants :

Opérations HEMS avec treuillage, et/ou

Opérations HHO sur le type de machine, et/ou

Expérience globale du postulant au regard de son activité HHO antérieure, et/ou

L'environnement géographique global dans lequel le candidat a développé son expérience en vol."

Training

"Dès lors que les critères mentionnés ci-dessus sont favorables, le postulant suivra une formation pratique complémentaire adaptée au milieu et aux conditions souhaitées. Trois modules sont ainsi proposés.
Chacun des modules sera constitué de cours ou briefings adaptés à l'expérience du postulant, puis des vols."

4. Training programme

The ground training consists of 14 modules for a total duration of 13 h and 30 min of lessons and a theoretical test.

The flight training for the "Initial HHO" qualification involves three flight sessions totalling a duration of five hours and comprising 45 hoist operations. This training is followed by a check flight lasting 30 minutes and five hoist operations.

Depending on the helicopter's type of operation, flight training for the "Advanced HHO" qualification involves:

- For HHO operations in mountainous areas: three flight sessions, each lasting one hour and comprising eight hoist operations.
- For night-time HHO operations: two flight sessions, each lasting one hour and comprising eight hoist operations.

Appendix 9: Risk map associated with SPA.HHO operations

Cartographie des risques - SPA.HHO - Version 2 - 12/10/2020

N° risque	DANGER	EVENEMENT INDESIRABLE	SANS BARRIERE DE PREVENTION			BARRIERES DE PREVENTION	AVEC BARRIERE DE PREVENTION		
			Probabilité	Gravité	Résultat		Probabilité	Gravité	Résultat
1	Echec de communication dans l'aéronef entre équipages	Collision avec obstacles, incident, accident	Possible	Moderate	High	Formation aux règles de communication gestuelle entre membres d'équipage Interruption de la mission si le pilote le juge nécessaire	Possible	Minor	Medium
2	Liaison hélico-personne transportée-paroi	Enfoncement avec puissance, accident, dommages à des tiers, collision	Possible	Major	Extreme	Formation du pilote et du treuilliste Formation du secouriste Coupe-câble treuil Briefing avant la mission	Possible	Moderate	High
3	Mission de treuillage : manque d'entretien de l'optionnel, câble, émerillon, crochet et fixation, etc…	Panne du treuil pendant le treuillage, interruption de la mission et perte de temps	Possible	Major	Extreme	Maintenance programmée sur le treuil dans le cadre du P.E EC 135 de la compagnie (PARTM).	Possible	Minor	Medium
		Augmentation de la probabilité de perte de charge au cours du vol	Possible	Major	Extreme				
4	Surcouple moteur, dépassement limitation de puissance	Détérioriation, coût de maintenance, immobilisation, coût commercial	Possible	Major	Extreme	Respect des limitations définies Formation du pilote Préparation du vol, notamment Devis de Masse et Centrage Brite saver + VEMD	Possible	Minor	Medium
5	Vol avec portes ouvertes ou déposées	Chute d'un article en cours de vol, ou pire, chute d'un membre d'équipage ou d'un passager pendant le vol	Possible	Major	Extreme	Formation et expérience des membres d'équipage Briefing passagers Equipement de sécurité du treuilliste Arrimage matériel	Possible	Minor	Medium
6	Changement de trajectoire	Perte d'attention entraînant l'incident ou l'accident	Possible	Moderate	High	Formation CRM du personnel impliqué (Pilotes, assistant de vol) Communication avec le personnel au sol	Unlikely	Moderate	Medium
7	Corps étrangers	Destruction de l'aéronef, incident, accident	Possible	Major	Extreme	Communication SGS sur les risques FOD via des Infos Sécurité Sécurisation du matériel utilisé et non fixé à l'aéronef	Unlikely	Major	High
8	Distance de sécurité de l'aéronef avec les obstacles trop faible	Collision avec obstacles, incident, accident	Possible	Catastrophic	Extreme	Préparation de la mission (reconnaissance zone) Formation, expérience de l'équipage Présence d'un TCM/treuilliste à bord Communication avec le personnel sol	Possible	Moderate	High
9	Echec de la liaison radio avec l'équipe au sol lors de missions	Répercussions sur la sécurité du vol et du personnel/ tier impliqués	Possible	Moderate	High	Insister sur ce point lors du briefing pré-vol, envisager tous les scénarios possibles (obstacles, la position de la charge, etc.) Code/gestuelle pour l'échange de signaux optiques entre le pilote et l'opérateur du treuil	Possible	Moderate	High
10	Le personnel n'est pas formé ou manque d'expérience récente	Répercussions sur la sécurité du vol et du personnel/ tier impliqués	Possible	Moderate	High	Formation SPA.HHO Expérience récente nécessaire définie Expérience des missions treuillages Formation SAMU	Unlikely	Moderate	Medium

The BEA investigations are conducted with the sole objective of improving aviation safety and are not intended to apportion blame or liabilities.