CIAIAC

COMISIÓN DE
INVESTIGACIÓN
DE ACCIDENTES
E INCIDENTES DE
AVIACIÓN CIVIL

Report
EXT Andorra 2011

Accident involving
an AS 350 B3 helicopter,
registration EC-LHP, operated
by Heliand (CAT Helicopters),
in Pleta de Juclar (Canillo –
Principality of Andorra),
on 15 June 2011

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Foreword

This report is a technical document that reflects the point of view of the Civil Aviation Accident and Incident Investigation Commission (CIAIAC) regarding the circumstances of the accident object of the investigation, and its probable causes and consequences.

In accordance with the provisions in Article 5.4.1 of Annex 13 of the International Civil Aviation Convention; and with articles 5.5 of Regulation (UE) n° 996/2010, of the European Parliament and the Council, of 20 October 2010; Article 15 of Law 21/2003 on Air Safety and articles 1, 4 and 21.2 of Regulation 389/1998, this investigation is exclusively of a technical nature, and its objective is the prevention of future civil aviation accidents and incidents by issuing, if necessary, safety recommendations to prevent from their reoccurrence. The investigation is not pointed to establish blame or liability whatsoever, and it's not prejudging the possible decision taken by the judicial authorities. Therefore, and according to above norms and regulations, the investigation was carried out using procedures not necessarily subject to the guarantees and rights usually used for the evidences in a judicial process.

Consequently, any use of this report for purposes other than that of preventing future accidents may lead to erroneous conclusions or interpretations.

This report was originally issued in Spanish. This English translation is provided for information purposes only.

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Abbreviations

00 °C	Degrees centigrade
AESA	Spain's Aviation Safety Agency
ALF	After Last Flight
AMT	Aircraft Maintenance Technician
ARC	Airworthiness Review Certificate
ATC	Air Traffic Control
BEA	Bureau d'Enquêtes et d'Analyses (French Bureau responsible for investigating the safety of civil aviation)
BFF	Before First Flight
BTP	Boîte de Transmission Principale (main gearbox)
CAMO	Continuous Airworthiness Management Organization
CIAIAC	Comisión de Investigación de Accidentes e Incidentes de Aviación Civil
cm	Centimeter(s)
CPL(H)	Commercial Pilot License (Helicopter)
DECU	Digital Engine Control Unit
FH	Flight Hours
GPS	Global Positioning System
h, hr	Hour(s)
HIL	Hold Item List
IFR	Instrument Flight Rules
JAR-FCL	Joint Aviation Regulations – Flight Crew Licenses
kt	Knot(s)
LH	Left Hand
m	Meter(s)
RH	Right Hand
S/N	Serial Number
TLB	Technical Log Book
UTC	Coordinated Universal Time
VEMD	Vehicle Engine Monitoring Display

Synopsis

Owner and operator:	Heliand (CAT Helicopters)
Aircraft:	Eurocopter AS 350 B3, registration EC-LHP
Date and time of accident:	Wednesday, 15 June 2011; at 07:45 h[1]
Site of accident:	Pleta de Juclar (Canillo) Principality of Andorra
Persons onboard:	1 pilot, 1 mechanic and 4 operators: 5 of them killed and 1 seriously injured
Type of flight:	Aerial work – Commercial – Construction/sling load
Date of approval:	25 September 2013

Summary of accident

On 15 June 2011, at about 07:30 h, a Eurocopter AS-350-B3 helicopter, registration EC-LHP, was on a personnel transfer flight from a staging area located in the vicinity of Pont d'Incles to the Juclar shelter, located next to Estany Primer de Juclar (Canillo – Principality of Andorra)[2]. Weather conditions were good with little wind and clear skies. Onboard were the pilot, the helicopter's maintenance technician, four operators and a dog belonging to one of the operators.

Immediately prior to this flight, the pilot and the mechanic had transported an external load on a 10-meter long sling from the base camp, located in the Massana area, to the area where the load was unhooked[3] and the personnel boarded to head to the shelter. Shortly before arriving at the shelter, the sling previously used to carry the load and which was still attached to the hook on the helicopter, fouled the branches of a pine tree. The branches broke, freeing up the sling. The helicopter changed its path slightly, impacting another pine tree before crashing to the ground 15 m further forward and catching on fire. Five of the six occupants perished and the sixth was seriously injured with burns to 70% of his body. The dog was also injured.

The main wreckage, along with pieces of cut and torn tree branches, minor helicopter components and parts of the sling, were found some 100 m away from a wooded area along the flight path. The sling was found some 85 m to the right of the main wreckage, in the direction of the helicopter's original heading. It was cut in two pieces spaced 25 m apart.

[1] All times in this report are in UTC unless otherwise specified. To obtain local time, add two hours to UTC.
[2] See Appendix A.
[3] See Appendix A.

Taking part in the investigation were the government of Andorra, France's aviation safety investigating agency (BEA[4]), and the manufacturers of the helicopter (Eurocopter), engine (Turbomeca), sling (Texbor) and load hook (Onboard Systems).

The investigation concluded that the crew was not aware that the sling was still attached to the hook on the helicopter and flew at a lower altitude and faster than it should have, causing the sling to foul the branches of a pine tree at the top of the crags, resulting in the loss of control of the aircraft followed by its impacting against another pine tree.

[4] BEA: Bureau d'Enquêtes et d'Analyses is the French agency responsible for investigating the safety of civil aviation.

1. FACTUAL INFORMATION

1.1. History of the flight

On the morning of Wednesday, 15 June 2011, the helicopter was making several sling[5] load flights in another area. After completing this work, it headed to the company's base (la Massana), where two cages were loaded onto the sling. One was empty and the other had a diesel drum, which was also empty[6]. Onboard the helicopter were the pilot, seated in the RH seat, and the aircraft maintenance technician (AMT, hereinafter "mechanic"), seated in the LH seat. They flew northeast, toward the Incles bridge (see Appendix A), where several operators were waiting for them with the load of supplies to be taken to the Juclar shelter, located near the Juclar Lake in the Incles Valley, and which was being refurbished prior to its opening. According to the accounts of the operators who were waiting to go up the shelter on the next flight, once there, the helicopter left the cages on the ground and a third individual released the safety hook from the sling to unhook the load. The helicopter then flew to the right side, where it set down the sling and landed on a southwesterly heading with the sling atop the center of the skids, the load to its left and the engine running (see Figure 1). The counterweight being carried by the sling to keep it from swinging during flight, and

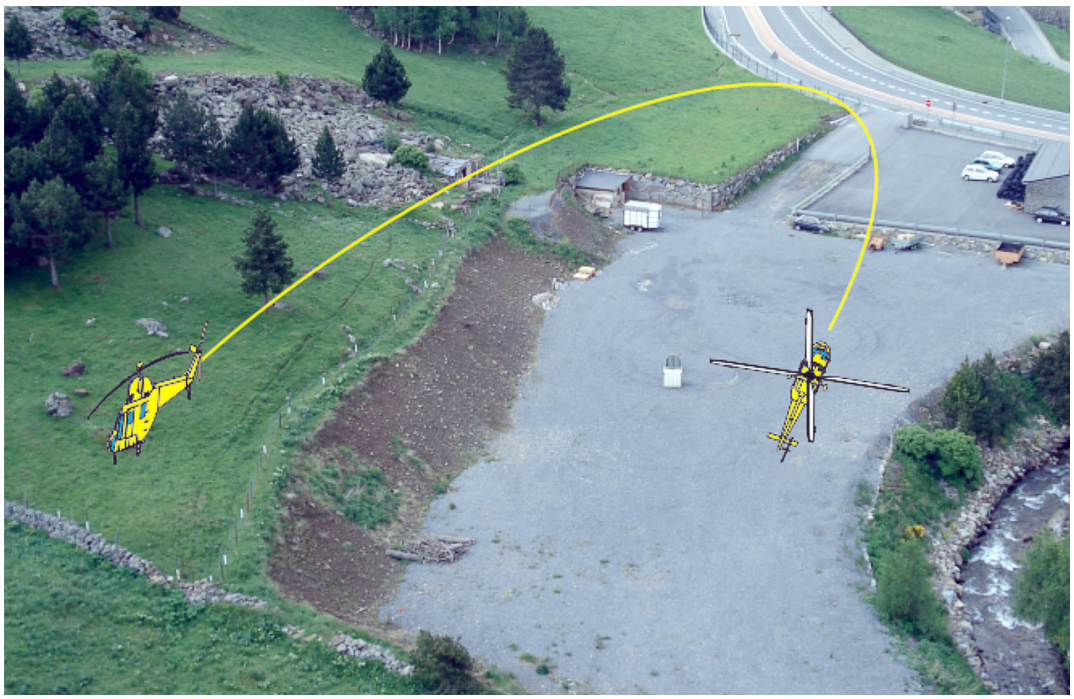


Figure 1. Site from which the helicopter took of for the shelter and where the load was dropped off

[5] Woven ribbon, normally flexible, with eyelets at each end that joins the suspension ring (inside the external load hook from which the sling is suspended) with the load.

[6] The external load system consisted of a 10-meter long sling with a load hook at its end, from which hung a counterweight system consisting of a cylinder with a nail hook at the end. The cages were suspended from this final hook.

featuring the same attachment system as on the external load hook[7], remained with the load (cages) instead of being attached to the sling.

During the first few flights the operators were going to be taken to the shelter, and then the load would be transported. On this initial flight to the shelter were two technicians, who were going to check the water purifier, a maintenance technician who worked for the city of Canillo, and the custodian of the shelter and his dog. The helicopter mechanic, located in the left side of the cockpit, exited the helicopter to help the operators board it, also via the left side and, once everyone was onboard, to ensure the door was closed properly.

At around 07:00, the helicopter took off, ascending vertically and turning left 180° to fly to the shelter by way of the Incles valley. As it took off, personnel on the ground noticed that the sling remained attached to the helicopter, which was unusual during personnel transfer flights. Another eyewitness located parallel to the takeoff flight path made the same observation, underscoring the fact that the helicopter was flying very low and how the sling may have even impacted the frame of a billboard adjacent to the takeoff area.

The helicopter continued on its route to the valley that would take it to the shelter. Some 2,500 m further along on its path, two eyewitnesses, forest rangers working in the area, saw the helicopter flying at a low altitude, approximately 100 m above the road, with the sling hanging below it. One of them stated that on noticing the sling, he continued looking at the helicopter until it disappeared above some crags upon reaching the summit (just before the accident site). He did not notice any strange maneuvers. The eyewitnesses immediately heard a loud noise, reported this on the radio to their supervisors and proceeded to the area.

Another eyewitness, the first to reach the accident site, said that he was hiking in the area and saw the helicopter fly overhead when he was near the crags. It passed to his right toward the crags and had "an orange rope hanging underneath"

The accident took place once the helicopter cleared the crags. The sling wrapped around the branches of a pine tree at the top of a crag and the helicopter impacted another pine tree located on the north shore of a stream. The wreckage was at a 270° angle with respect to the original flight path and impacted upside down. A fire broke out after the crash. The aircraft was destroyed. Five of the helicopter's occupants, including the pilot and mechanic, died as a result of the impact. Four of them were affected by the fire and the fifth was ejected from the aircraft. The sole survivor had burns over 70% of his body. The dog was injured.

[7] Hook-shaped device mounted on the bottom of the fuselage from which the loads are suspended. This hook normally features both a normal and emergency opening system.

The hiker who witnessed the accident reached the site in a couple of minutes, followed some 20 minutes later by the two forest rangers. The fire had gone out by then and they tended to the injured man while at the same time looking for other survivors and ascertaining the situation.

1.2. Injuries to persons

Injuries	Crew	Passengers	Others
Fatal	1	4	
Serious		1	
Minor			Not applicable
None			Not applicable
TOTAL	1	5	

1.3. Damage to aircraft

The aircraft was destroyed as a result of the impact and the fire that broke out afterwards (see Section 1.12).

1.4. Other damage

Not applicable.

1.5. Personnel information

The pilot, a 61-year old French national, had a JAR-FCL commercial pilot license (CPL(H)) issued by the French authority with the AS350/B3/EC130B4, EC135SP, SA316/319/315 ratings on the date of the accident, as well as a nighttime rating, all of them valid and in force. He also had a valid and in force class 1 medical certificate.

Based on the information contained in his aviation records, the pilot had been rated and had experience on other helicopter models, as well as an IFR rating, although on the date of the accident these ratings had not been renewed.

The pilot had 13,677 flight hours and ample experience in cargo and positioning operations in the mountains, fighting fires in mountains, sling operations, rescue operations, working on high-voltage lines and thermal vision surveillance. His aviation

record showed that he had 12,650 flight hours, of which 500 had been at night and 600 in IFR conditions.

The company reported that the pilot had made about 23 flights to the same site where he was flying on the day of the accident, 18 of them in the first months of 2011.

1.6. Aircraft information

1.6.1. *General information*

The accident aircraft was a Eurocopter AS-350-B3 helicopter, registration EC-LHP, with serial number 4916. It had been built in 2010. It was outfitted with a Turbomeca Arriel 2B1 engine, S/N 46430. The aircraft was owned by HELIAND (CAT HELICOPTERS). At the start of the accident flight the aircraft had 356:35 flight hours.

The helicopter had a registration certificate, an aircraft station license, noise certificate and insurance certificate, all of them valid an in force. It also had an airworthiness

Figure 2. View of the accident aircraft

certificate and the corresponding airworthiness review certificate (ARC), issued by AESA on 08 July 2010. The ARC had been extended for one year by the company's own CAMO on 21 February 2011.

Both the aircraft and engine log books were destroyed in the accident.

1.6.2. *Description of the helicopter's load system*

The helicopter was equipped with a CARGO SWING load hook, which consists of an external load hook integrated in a pyramid frame structure (hereinafter "cradle") that is attached to the fuselage using four cables that limit the swing of the load (see Figure 3).

The helicopter had two independent systems for releasing the load/opening the hook:

Electrical Release. This system includes a load indicator, a pre-arm switch for the electrical system on the control panel (SLING) and a hook opening button on the cyclic stick (see Figure 4). The hook opening button cannot be activated if the system is not pre-armed.

Emergency Mechanical Release. This system includes a lever located at the bottom of the collective lever that is directly wired to the hook (see Figure 4).

Figure 3. Structure of the CARGO SWING unit similar to the one on the accident helicopter

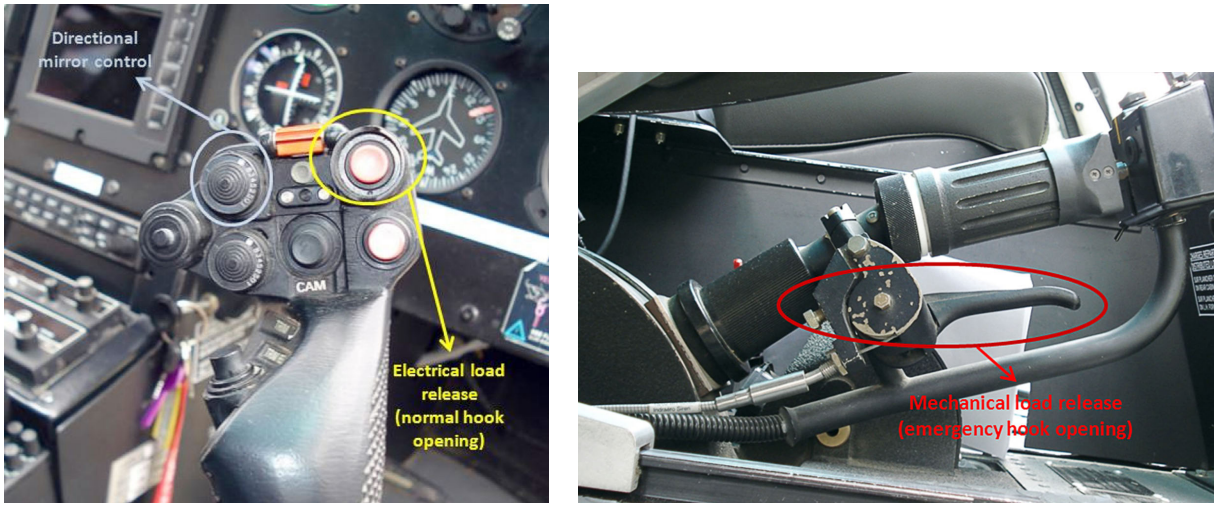


Figure 4. Load release mechanisms in the cockpit

There is also a manual load release handle on the hook itself for use outside the cockpit (see Figure 5).

The helicopter featured two rearview mirrors that allowed the pilot to see both the location and the movement of the load. These mirrors were controlled via the cyclic stick.

A cylindrical counterweight was normally hooked onto the end of the sling to stabilize it on unloaded flights. The hook used to attach the counterweight to the sling is identical to the one on the end of the sling and features a safety hook system.

Figure 5. Load hook

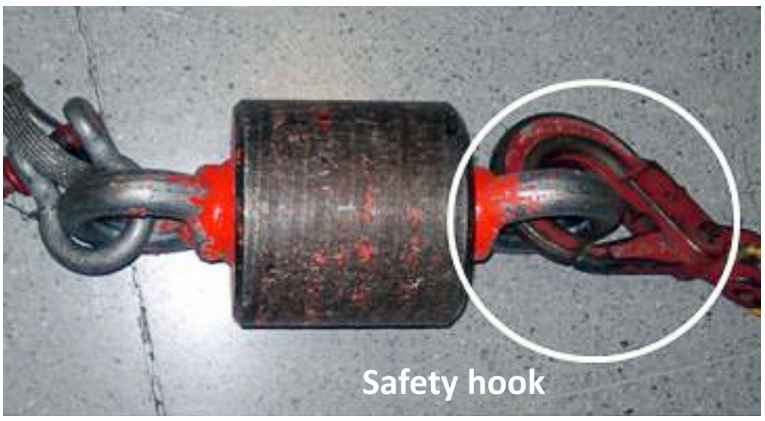


Figure 6. Counterweight

1.6.3. *Maintenance information*

The aircraft had a maintenance program, the last revision of which had been approved by the AESA in April of 2011. This program was based on the maintenance instructions published by the airframe (Eurocopter) and engine (Turbomeca) manufacturers, and also considered the Airworthiness Directives issued by the European Aviation Safety Agency. The aircraft had passed its last inspection (a 100-hr check) on 10 May 2011, at which time it had 304 flight hours. The following inspections had been performed:

- With 100 FH (5/10/2010, 101/110-hr inspection)
- With 204 FH (23/12/2010, 200-hr inspection), and
- With 298 FH (5/05/2011, 300-hr inspection).

An engine power diagnosis was also run every 20 h. The last of these had been performed on 05 June 2011 with 349:45 FH.

The flight log on the day of the accident listed a BFF (before first flight) inspection and the flight log for the previous flight (14 June 2011) listed an ALF (after last flight) inspection. The technical logbook (TLB) where the periodic maintenance activities were recorded showed that all of these inspections had been carried out within the specified limits. No hold items had been recorded in the HIL (hold item list) since the helicopter started operations (August of 2010).

The maintenance requirements for the external load system were included in the maintenance program. The hook attachment structure was subject to a periodic inspection as part of the 100-hr check during which the structure was verified to be free from ovalization caused by excessive loading. The hook had a lifetime between overhauls of 1,000 h, specified in terms of flight hours with an external load (not cycles), or a maximum of five years.

1.7. Meteorological information

The meteorological information gathered for the time of the accident, around 07:00 UTC in the principality of Andorra, called for sunny conditions in the morning with cumulus clouds forming in the afternoon, resulting in local showers.

The wind at 1,500 m was variable and weak (between 2.7 and 5.5 kt), at 3,000 m it was from the west at between 5.5 and 11 kt. The maximum temperatures in the area were around 26 °C for Andorra la Vella, 14 °C for Pas de la Casa and 22 °C for Soldeu.

1.8. Aids to navigation

Not applicable.

1.9. Communications

There were no communications either with ATC stations or with the company's base.

1.10. Aerodrome information

Not applicable. The helicopter had taken off from its base at La Massana and headed to a flat clearing to use for staging operations involving material for the shelter (see Figure 1).

1.11. Flight recorders

There were no flight recorders onboard, as they were not required for this aircraft type. This helicopter did, however, have several systems for monitoring and storing parameters:

The DECU[8], located in the engine compartment, had been damaged by the fire and was opened, which had exposed its internals to the fire as well. Several chips were found underneath it and recovered in case they could be read. The engine manufacturer later confirmed that it had been unable to recover any data from them.

The instrument panel housed VEMD[9], GPS[10] and Brite Server units. All had been damaged by the fire, meaning the information contained in them or that they may have displayed could not be recovered.

[8] Digital Engine Control Unit.
[9] The VEMD (Vehicle Engine Monitoring Display) is the interface between the DECU and the pilot. It displays engine parameters on its screen.
[10] Brite Server: Unit located on the instrument panel that stores engine data for flights made.

1.12. Wreckage and impact information

1.12.1. *Description and arrangement of the wreckage*

The main aircraft wreckage was found atop one of the crags. It was rotated at a 270° angle with respect to the flight path and upside down, with the helicopter's skids facing up (see Appendix B).

Some 50 m ahead of the wreckage, just at the start of the crag, there was a group of black pines, the branches on one of which were cut. The pine was about 8 m tall and the signs of damage started some 3 m from the top. The broadest and most damaged branch was found torn from the trunk and evidenced signs of friction and abrasion as well as a clear groove around the part without any bark (see Figure 7). Other, smaller branches above this one had also been torn from the trunk and were being held up by the undamaged branches.

Between that pine tree and the impact area there were scattered branches and bits of the polyamide-nylon mesh and core of the sling, the protective plastic sheath of its top end, still bearing a label with the specifications (length, load factor, composition, etc.) and cut lengthwise, as well as blade fragments (fiber and foam) later identified as being from the tail rotor.

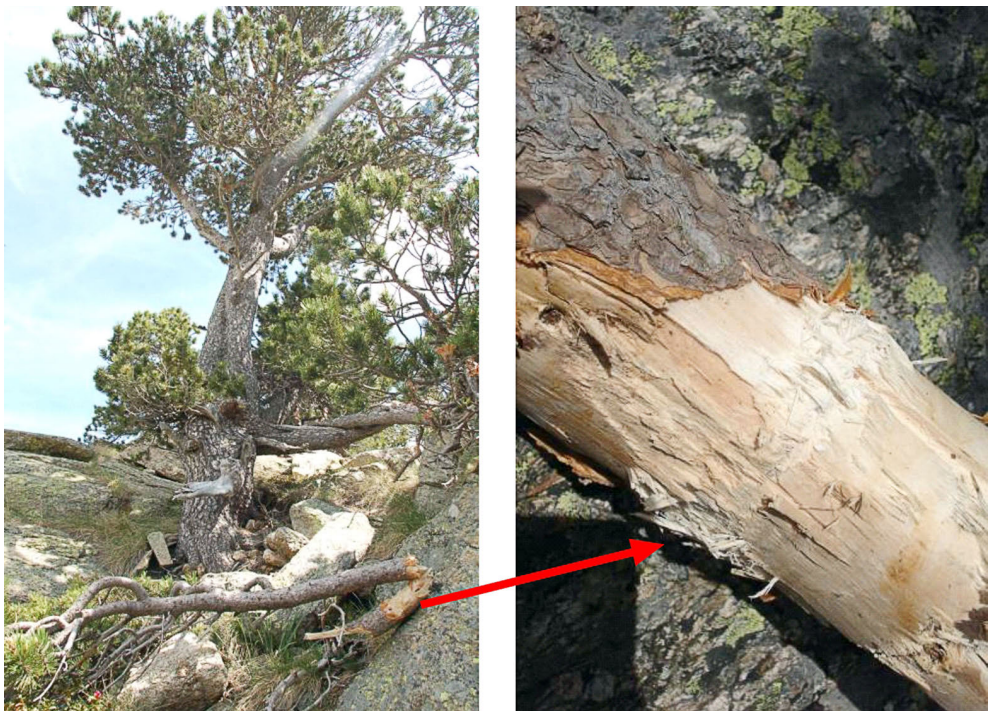


Figure 7. Branch abraded by the sling

Upon reaching the site of the main wreckage, a pine tree was found with the ends of its branches cut, but not torn out. Also found were the remains of another pine tree that was completely split, there being very little left of its trunk, with the remaining pieces being found between the trunk and the main helicopter wreckage. To the left of the pine tree in the direction of the flight there were three marks on the rock at varying heights, the lowest of them filled with dirt. The average distance between the marks and the split pine tree was about 6 m. Alongside the torn off parts there were components from the floor of the cockpit where the tail rotor control pedals were attached, the pitot tube and dark glass from one of the cockpit doors. The cockpit and the engine were consumed by the fire and were at a 270° angle from the aircraft's original flight path.

Figure 8. Damage to the right skid

The skids and the load hook cradle were facing up. Although subjected to the fire, they retained most of their structure, except for the bottom bar on the cradle, which was found with its rubber coating, and the aft part of the left skid, which was undamaged by the fire and found just ahead of the main wreckage (between it and the impacted pine tree). The aft part of the right skid indicated that the skid structure had been torn off by another metal component (see Figure 8). The load hook was in the closed position with no traces of the sling.

The instrument panel was damaged by the fire, as had the equipment installed in it. It was found in the part of the cockpit where the cyclic control should have been. The collective lever was found near the area where the tail cone attaches to the cockpit, but on the outside. The engine was located among the burned wreckage and the leading edges of its compressor blades were found with impact damage.

The tail cone, which was undamaged by the fire, was attached to the cockpit structure, forming a 60° angle with the longitudinal axis of the engine. The tail rotor's two blades remained attached to the structure, though one exhibited a loss of material at one end. There were no dents on the rest of the blade and its length was practically the same as the

Figure 9. Marks on one of the main rotor blades

other blade's. There was continuity in the transmission from the last segment of the axis to the right-angle gearbox and the rotor outlet.

The assembly consisting of the main gearbox, the mast and the main rotor was torn from the airframe and underneath the main wreckage. The three blades remained attached to the rotor head. Two of them were damaged by the fire, and one was bent by a rock below the mast. The tip on the left blade was worn and had soil remnants on it. Its tip was damaged. There were two parallel notches, 2 and 3 cm wide, in the burned area of the blade that had been bent. These notches were some 250 cm away from the blade root, on the leading edge of the blade.

The controls and servos exhibited continuity to the rotor head. The main driveshaft from the engine to the BTP[11] was broken on the BTP side and showed significant signs of twisting stress (see Figure 10). The swash plate assembly had been pushed up toward the rotor head and also showed signs of twisting. The attaching rivets had been sheared off. It was proposed that a detailed inspection of the main gearbox be conducted after the fact so as to rule out any failure of this component.

The sling was found on the other side of the stream, to the right of the helicopter's flight path and some 80 m away from the main wreckage. It was cut in two. The bottom part, of 4.5 m in length and with the safety hook still attached to it, was more or less aligned with the main wreckage. The remaining 5.5 m of sling was found with the ring for attaching it to the helicopter. It was about 25 m away from the other part, aligned with it and parallel to the helicopter's flight path.

Figure 10. Fracture of the main driveshaft on the BTP side

[11] BT: Boîte de Transmission Principale – Main gearbox.

1.12.2. *Inspection of aircraft components*

1.12.2.1. Powerplant

With the aid of the engine manufacturer, which, along with the BEA, traveled to the accident site, an onsite inspection of the engine and the DECU was conducted.

The analysis following the visual inspection revealed the following:

- The damage to the leading edge of the blades on the compressor wheel and the debris found in the direction of the incoming air indicated that the power generating part of the engine was rotating at the time of the incident.
- The main driveshaft from the engine to the BTP had fractured on the BTP side and showed signs of having failed under considerable torsional stress.
- The fracture of the driveshaft resulted in the turbine sudden acceleration up to the design blade shedding speed[12]. The damage found on the reinforced outer casing was caused by the energy of the detached blades.

The damage caused by the fire meant that no information was recovered from the DECU or from the associated equipment in the cockpit (VEMD).

Figure 11. Damage to the blades

1.12.2.2. Sling

The sling was cut into two pieces of approximately the same length (4.5 and 5.5 m). An examination alongside personnel from the BEA and the aircraft and sling manufacturers revealed that:

[12] Blade Shedding- design safety feature in which the blades of the free turbine detach at a speed below the bursting speed of the free turbine's disk.

- The separation into two pieces was more likely due to a cut than a tear.
- The part with the safety hook attached was 4.5 m long and was abraded near the area of the hook, which had wooden splinters.
- The metal end cap was twisted and elongated.
- The part that was cut showed signs of abrasion and there appeared to be grayish paint on the orange mesh of the sling. A sample of the mesh, and another from a main rotor blade, were sent to the BEA for analysis.
- The remaining 5.5-m long part was still attached to the ring used to hook on to the helicopter.
- The ring was intact and, at first glance, did not show any abrasion. The part used to attach this ring to the sling through a metal reinforcement was missing its protective sheath and parts of the resin-impregnated rope that reinforce the end piece.
- The part closest to the break showed signs of abrasion and there were indications that the sling had been stretched.

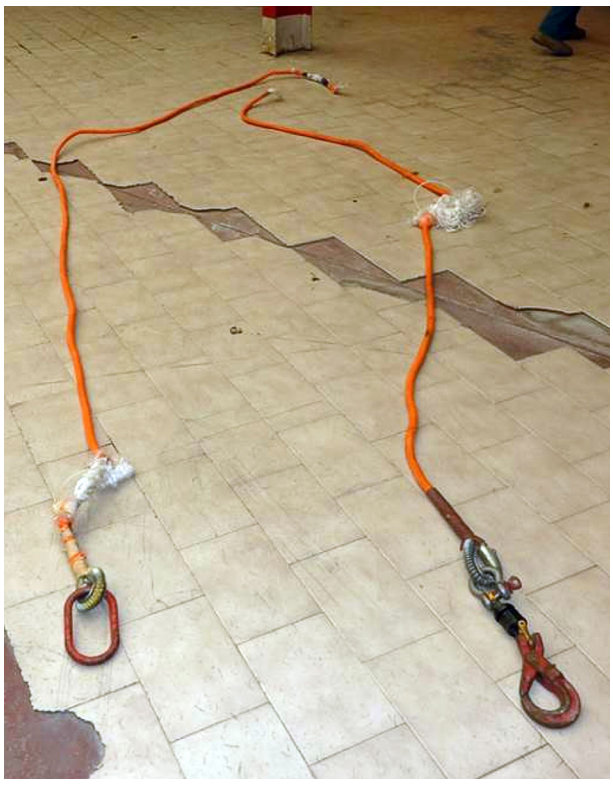


Figure 12. Sling

A clean portion of the sling, the paint on the main rotor blade (clean area) and a part of the impregnated sling were chemically analyzed. The findings indicated that the composition of the paint on the blade was the same as that deposited on the sling with the exception of some chlorine and potassium deposits, which could have originated from materials that tainted the samples. The laboratory noted, however, that the technique used was not sufficient to determine scientifically if the paint was the same.

1.12.2.3. Main driveshaft

The main driveshaft was analyzed in a hangar in an effort to rule out any mechanical faults of this component. This inspection was carried out by experts from the manufacturer, in concert with expert CIAIAC consultants. The conclusion reached was that the damage found was consistent with an impact and that no signs were found indicative of a failure of the main driveshaft components.

1.12.2.4. Hook

In a similar fashion, the hook was inspected by the manufacturer at the CIAIAC's facilities with CIAIAC personnel present. The hook, despite having been exposed to the fire, appeared to be in fair condition. It was found in the closed position and was not attached to the sling. The electrical connector was destroyed. The bumper was apparently consumed in the fire and the mechanical connector was damaged. There was also a mark on the surface of the latch. The hook remained closed and could not be opened using the manual release handle. It was disassembled. The mechanical wire was properly hooked to the handle, which, although it rotated correctly, would not open the latch. The entire electrical assembly had been damaged in the fire, making it impossible to test the hook for proper electrical operation. Once the covers were removed, the latch was able to move without any problem. The entire length of the actuating wire, from the hook to the collective lever, was accounted for except for 50 cm. In light of the damage found during the disassembly, it was concluded that the hook had not been opened by an overload condition.

The possibility remains that the geometric configuration of the hook and the sling hooking system (end piece, end cap and plastic label listing the characteristics of the sling) during the landing could have been such that even with the system armed, the sling may not have fully released. The hook would, however, have remained open and the sling could have fallen due to gravity during the flight.

Figure 13. Disassembled hook

1.13. Medical and pathological information

The autopsy report concluded that the immediate cause of the death of the aircraft's occupants was hypovolemic shock due to multiple traumas, as well as the burns that affected five of the occupants due to the fire.

1.14. Fire

The fire broke out after the impact with the ground. Most of the aircraft and its components were damaged by the fire. According to the forest rangers who responded to the crash, by the time they reached the scene, some twenty minutes after the impact, the fire had gone out.

1.15. Survival aspects

Given the nature of the accident, it was highly unlikely that the aircraft's occupants could have survived it.

1.16. Tests and research

In light of the damage, breaks and the condition of the various helicopter components (skids, hook assembly, main rotor blades and sling), a hypothetical scenario was formulated and tested that accounted for all of the factors involved. This simulation was carried out in the presence of the parties involved in the investigation (BEA, Andorran government officials, aircraft manufacturer and the CIAIAC), who endorsed its results. The damage and distortions to the skids, hook, sling and blade indicated that the accident sequence could have been as follows:

- When the helicopter cleared the crags, the sling may have become ensnared on the branches of the black pine, fouling one of them.
- The main structure experienced complete deceleration with the engine and main rotor turning at full power.
- Due to this fouling, the entire sling assembly, including the cradle and the hook, was subjected to great stress.
- The helicopter then pitched down and turned right due to the motion of the blades, which caused the sling to pass underneath the right skid.
- As a result of this, the entire cradle assembly was subjected to a large amount of stress, which bent the aft bar on the cradle.
- Due to the breaking of the branch, the sling could have been slingshot upward, where it impacted one of the main rotor blades, fouling it as well.
- The helicopter pilot then likely lost control as the helicopter impacted another black pine in its path, which caused the airframe to break up, the blades to strike the rocks on the ground to the left and the structure to overturn into its final position.
- The force of the rotor blades caused the aft bar on the forward wire of the hook cradle to break. The aft bar was found near the main wreckage, alongside the impacted pine tree and it was not damaged by the fire.
- The hook finally opened, probably as a result of the breaking of the cable connecting it to the collective when the helicopter impacted the pine tree and of the subsequent break-up of the cockpit.

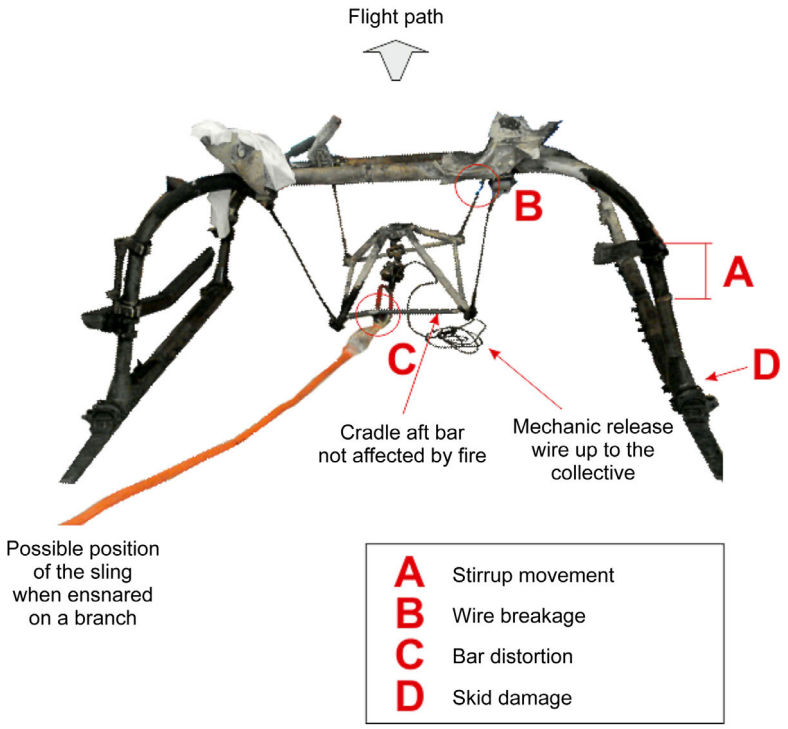


Figure 14. Damage to the hook cradle and skids

Figure 15. Reconstruction of the position of the sling in the rotor blades

- The sling was released but, due to the rotating action of the blades, was dragged by the blades. During this, the end cap on the ring that attached the sling to the hook struck the right skid and cut it, and finally produced an upward movement of the stirrup.
- It was probably this cut that tore the label on the sling, located after the end cap, longitudinally and detached it.
- The sling was cut when it fouled the blades and was ejected in two parts across to the other side of the stream.
- The main rotor detached from the airframe probably due to the sudden stoppage during the impact, causing the airframe to keep rotating before eventually turning over.
- The fuel burned and flowed down the rock due to gravity, which spared some parts of the structure, such as the tail cone and one of the blades, from the fire.
- A small notch was found on the latch on the hook that was probably produced on impact and that could have caused it to close before the fire eventually jammed the system in manual mode.

1.17. Organizational and management information

According to its responsible, the aircraft was operated by CAT Helicopters, a commercial brand that was represented in Andorra by Heliand. Its activities in Andorra were defined as aerial work.

Part A of the operator's Operations Manual, on the transportation of loads, specifies the equipment required on helicopters used for external load operations, as well as the instructions that the captain must give to ground personnel prior to starting a flight, as listed below:

- Wrapping and bundling of loads.
- Hooking the loads.
- Emergency release from the outside.
- Static discharges.
- Safety around and underneath the helicopter.
- Visual signals in case of a radio failure.

The captain shall also specify the point where the load is to be hoisted from and where it will be set down, calculating the turn-around times and the aircraft refueling sequence, as well as the amount of fuel to be taken on during each refueling. Before the flight the captain shall also check the automatic and manual hook opening modes for proper operation from inside the cockpit. He shall also check the release system from outside the cockpit and the position of the mirrors.

The climb with the load is to be initiated vertically, controlling the helicopter's power before immediately transitioning to translational lift into the wind while monitoring the load for swinging and the speed of the helicopter.

To set down the load, a smooth approach will be made by controlling the power of the helicopter and the height of the load above the ground so as to avoid any sudden contact between the load and the surface where it is to be deposited. The captain shall ensure the load is properly released by using the mirror.

At around the time of the accident, the operator was writing a specific manual for transporting external loads called "Specific activities manual – Transporting external loads with a helicopter". This manual provided greater detail on how to transport loads and specified, among other things, the presence of a helper, an employee of either the company contracting the service or someone on the operator's own workforce, who was properly trained on handling and hooking/unhooking loads. This helper was to be in constant communication with the pilot, who had to ensure the load was properly released from the sling using the rearview mirrors. This operation had to be carefully monitored on operations with an unloaded sling. This manual also established that passengers could not be transported during sling load operations.

1.18. Additional information

1.18.1. *Eyewitness statements*

The personnel who were preparing the load in the field, eyewitnesses to the landing and subsequent takeoff of the helicopter, Heliand personnel and eyewitnesses who were in the area when the helicopter left en route to the shelter were interviewed. The most relevant comments to the investigation are provided below.

The person who unhooked the load had been there since 06:00 because she was waiting for the nine propane gas bottles that had to be flown to the shelter. She had worked with the pilot and mechanic before and knew them well. The helicopter flew into the staging area with two cages, one empty and the other with a diesel tank. The helicopter placed them on the ground and she released the load hook. One of the cages tilted over, which she returned to an upright position. In the meantime, the helicopter landed, facing the road (southwest), and the operators started climbing onboard. The pilot, seeing how she had moved the cage by herself, made a gesture with his arm indicating how strong she was, to which she replied by blowing him kisses. Once the operators were onboard, the mechanic exited to close the door, and he too made a gesture in reference to her strength. The helicopter lifted off and when the sling was fully vertical, it turned around. The eyewitness saw nothing unusual in the flight, except for the hanging sling, since she had never seen the sling attached when passengers onboard. She had known the pilot for years and regarded him as prudent and expert, someone who handled the helicopter smoothly and fluidly. She recalled that the weather on that day was good.

The company's other pilot had been flying in Andorra since 2005-2006, and stated that the accident pilot had more experience, having flown there since 1995. Two years ago

the shelter had been refurbished, with both pilots flying on missions to transport material there. He said that the pilot was very methodic and they always flew the same route around the accident site, leaving it to the right on the way up and to the left on the way down. He wondered what he was doing on that side, since he should have flown to the left of it. He suspected that something could have happened to them because the area they avoided on the way up was the only flat area where they could make an emergency landing. That route was taken frequently, with a couple of trips made during summer days, most of them to resupply the shelter. The accident pilot had instructed this pilot and had told him that it was best not to divert from a known correct route. That is why he thought that something must have happened for them to fly toward the flatter area. That day they were going to make two personnel rotations. Regulations prohibited using a sling on passenger flights. The electrical system had to be pre-armed from the panel using the SLING option. The switch for activating the release was located on the cyclic control. He also stated that they never armed the sling when flying over roads or houses, since a load had been inadvertently released once. When doing loading flights (taking material up or down), then it was armed. They normally used the manual (emergency) release system. The sling was released with the helicopter on the ground so as not to damage the sling attachment by letting it fall. By procedure they always flew with a counterweight, except when flying near the load limit. They had 10, 20, 30, 40 and even 50-meter slings, as well as a 5-meter sling that they hardly used. They used the 10-meter sling because the chimneys on the shelters or the nearby crags impeded the use of the 5-meter sling. The helicopter had two rearview mirrors (high and low). The accident pilot said that if you could see the sling in the low mirror, you were going too fast and the sling was rising. Both the pilot and the mechanic were regarded as very methodical.

The remaining eyewitnesses at the staging area, who had flown more often with the pilot and were awaiting their turn to be flown up to the shelter, gave similar accounts of the event as that reported by the person who released the load. In general they added that they had flown with the pilot and mechanic previously, that normally the operators were flown up first and then the load, and in reverse order on the way down. All agreed that the sling was not used when carrying passengers and all were surprised when it took off and headed for the valley, noting that the helicopter was flying somewhat low to be using the sling.

An eyewitness who was working at a site across from the staging area on the other side of the river, perpendicular to the helicopter's longitudinal axis while it was on the ground, and who was used to watching helicopter operations involving the transportation of tree logs, stated that the helicopter dropped off the two cages it was carrying and landed. The last person, who was wearing an orange jumpsuit (mechanic), closed the passenger door, then climbed onboard and closed the door. The helicopter climbed vertically and made half a turn to the left to take off before pitching down and taking off. He recalled seeing some type of rope underneath the helicopter. He was very surprised to see a hanging rope because he had never seen it on passenger flights. It

seemed to him that the rope was going to hit some of the people in the staging area as it circled during the takeoff. A few meters away there was a metal frame from an old billboard whose top crossbar seemed to have been struck by the bottom of the rope. The same thing happened with a few pine trees a few meters further forward.

Two other eyewitnesses, forest rangers located in the valley along the helicopter's flight path as it flew to the crags, were working in an area that was approximately 2,500 m away from the takeoff site. The helicopter flew to their right level with the road some 100 m away. Below it was a 10-15 m sling that was at a steep angle. There was nothing hooked to the sling, except for what looked like a small ring and its components. One of forest rangers kept looking at the helicopter until he saw it fly over the last hill and disappear behind the crags. Then he heard a loud noise, like a *bluufff*, and immediately saw a column of black smoke. He remembered that everything had been normal until the crags. He did not see the helicopter make any unusual maneuvers. He immediately called his office to report the accident. Both rangers then went toward the area, first by car and then on foot. It took them about 20 minutes, during which they were in contact with their boss to fill him in on the details. By the time they reached the site the wreckage was smoldering. An emergency helicopter then arrived, along with firemen and the police. These eyewitnesses reported that the pines in the area are called black pines, which is the last tree species at that altitude. Black pines are harder than the common pine.

The first eyewitness to reach the accident site was walking on the path that climbs up to the Pleta de Juclar. He was near some crags that led to a tree. According to his account, it was shortly after nine (local time) when a helicopter emerged and flew at a low altitude over him. It surprised him because it was trailing an "orange rope" and it flew so close to him that it seemed he could almost jump up and reach it. Moments after flying over the crags he heard a noise that sounded like firefighters spraying water on a fire. He kept walking and soon smelled a strong odor of kerosene and of something burning other than trees.

1.19. Useful or effective investigation techniques

Not applicable.

2. ANALYSIS

That morning the helicopter had made several sling load flights in another area. After completing that job, the helicopter headed for the company's base camp (la Massana), where it picked up two cages, one empty and another with an empty diesel drum, to be carried using the sling. They were transported to a staging area located next to the Incles Bridge, where several operators were waiting to be taken to the shelter, along with a load of supplies. The operation was to be carried out as it normally was, with the personnel being taken up first (which would require two trips this time) and then the load. The helicopter dropped off the two cages and a third individual, known to both the pilot and the mechanic, unhooked the load. The helicopter then moved to its right, set down the sling and landed, leaving the sling on the central part of the skids, the load to the left and the engine running. The counterweight carried on the sling to keep it from swinging during the flight and keep it stable, and which was attached using the same system as on the external load hook (safety hook), remained with the load (cages), instead of being attached to the sling. In this regard, it should be noted that the person who unhooked the load, though used to doing this task, had not received specific training and, since the systems involved were identical, inadvertently unhooked the sling from the load instead of the counterweight.

In this regard, the investigation learned that the operator was writing a manual called "Specific activities manual – Transporting external loads with a helicopter", which considered the need for a properly trained helper to conduct load handling and unhooking operations. It also contained instructions for the pilot that underscored the need to check for the proper hooking/unhooking of loads. As a result, a safety recommendation was not going to be issued regarding the need for such procedures, but since this manual has yet to be approved or implemented, a safety recommendation is issued in this regard.

Both the helicopter pilot and mechanic were described as professional and methodical by their company colleagues and by the operators who were to be transported up to the refuge and who had worked with them before. It was possible that both confided in the know-how of the person who unhooked the load and assumed the sling had been detached without confirming this after the fact, as required by the procedures in Part A of the Operations Manual (see Section 1.17). The potential distraction provided by one of the cages almost tipping over and how this person was able to prevent it could have led the crewmembers to forget about the sling and to overlook the physical check, both in person and in the rearview mirrors. Though unlikely, it is also possible that the geometrical configuration of the assembly consisting of the hook and the sling hooking system (end piece, end cap and plastic identifying label on the sling) during the landing could have been such that, even though the hook opening system was armed and the hook opened, the end piece on the sling remained in the same position due to irregularities in the terrain of the staging area preventing the release of the sling. Had

Figure 16. Hook similar to the one in the accident, in the open position

this happened, however, the hook would have remained in the open position, making it easier for the sling to fall later during the flight. That is why this scenario is regarded as unlikely, though it cannot be ruled out.

Once the operators were onboard, the mechanic closed and latched the access door before he too climbed onboard. The mutual trust between the pilot and mechanic, both described as methodical and exacting and used to working together, could have resulted in the mutual delegation of the responsibility to check that the sling was detached.

In this case, considering the essential change in operations that is shifting from transporting a load to transporting passengers, it is necessary that a procedure be established that ensures the crew confirm the different helicopter configuration for the new operational condition. A safety recommendation is issued in this regard.

The helicopter took off vertically, turning left 180° to head toward the shelter via the Incles Valley. This takeoff was more brusque than one typically conducted with a loaded or unloaded sling, as specified in Part A of the Operations Manual, which states that the helicopter must lift off slowly vertically and once the load or sling is off the ground, shift to a translational motion. Eyewitnesses saw the helicopter climb while turning left to line up with the valley. They were all surprised to see the sling hanging down, as it was a passenger flight, and how low the helicopter was flying with the sling attached. One of them even thought that the bottom of the sling may have touched a billboard, though this was later confirmed not to have been the case. All of this, along with the description of the how the aircraft took off, indicate that both the pilot and the mechanic were convinced that the sling had been unhooked and that they were making a normal flight with passengers onboard, which is why they did not observe the altitude requirements for load operations or the precautionary

translational speed with a sling. They also would not have checked the position of the sling constantly in the mirrors.

The helicopter continued its path toward the valley that led to the shelter. Two eyewitnesses some 2,500 m further away saw the helicopter flying at a low altitude, with the sling hanging below it but at an elevated angle. Neither of them noticed any irregularities in the flight path indicative of any other problems with the aircraft. One of them, captivated by the way the helicopter was flying with the sling hanging below it, continued watching it until it disappeared behind the crags at the top of the hill. It was then that the accident took place. The last eyewitness was climbing up a path toward the crags. He also recalled seeing the helicopter emerge and fly to his right. He saw the rope hanging beneath it and remembered thinking that he could almost jump up and grab it. This coincides with the accounts of the low clearance altitude observed by the other eyewitnesses. A few seconds later he heard a noise similar to water being sprayed and started to smell smoke.

The inspections conducted of the main helicopter components, both onsite and afterward, revealed the following:

- At the start of the crags there were several pine trees, one damaged and with loss of branches, including one with signs of abrasion due to fouling.
- From that point forward until the main wreckage, there were pieces of sling and helicopter parts, meaning that can be considered as the point where the accident started.
- The position of the main impact pine tree coincided with a position of the aircraft in which the main rotor blades cut first the branches of the pine tree head of it and then impacted the rock to its left, leaving one of the blades covered in sand.
- There were two parallel 2- and 3-cm notches on the leading edge of one of the blades. Their width was consistent with two turns of the sling around the blade.
- There was continuity in the last part of the driveshaft on the tail rotor transmission from the right-angle gearbox outlet to the tail rotor.
- The main driveshaft from the engine to the BTP was broken on the BTP side. There was evidence of significant torsional stress causing the fracture, consistent with an abrupt stoppage after a sudden impact of the main rotor (tree or ground) with the engine under power.
- The detachment of the main rotor caused the airframe to rotate suddenly clockwise and possibly to overturn.
- The engine exhibited signs that it was turning and providing power at the time of the accident.
- The sling was cut into two parts of approximately equal lengths. The remaining damage had resulted from tearing due to a large stress and loss of mesh and core material between the fouled tree and the main wreckage. There were paint fragments on the mesh of the sling near the cut.
- The paint found on the sling and on the main rotor blade had the same constituent components.

The mechanical system on the hook was working. As for the chances that the hook may have opened and released the sling, the following considerations apply:

Electric opening: although the electrical release system could not be verified to be working properly, the release of the sling by the crew once they noticed it was caught in the tree can be ruled out since activating this system requires pre-arming it with the SLING switch, which was probably deactivated since the previous flight had been conducted over populated areas.

Opening due to overload: no evidence or damage was found to indicate that the hook or its attachment to the sling were overloaded.

Mechanical opening: the most likely option could have been actuated from the collective lever if the crew had noticed in time that the sling was attached. The fact, however, that the cable connecting the hook to the collective was practically intact suggests a possible fracture and tearing out of the lever on impact with the pine tree and the subsequent disintegration of the cockpit. This is also supported by the fact that the collective lever was found near the tail cone instead of among the remains of the cockpit.

In light of all the accounts, it seems that from the time the helicopter took off from the staging area until just before the accident, there was nothing unusual in its flight path to suggest a malfunction of the aircraft or a sudden change in its operation by the pilot. All the eyewitnesses reported a low and fast flight path with the sling attached. The fact that the pilot took a different route than usual can only be attributed to his desire to take that route. The helicopter did not behave erratically and had the pilot noticed the presence of the sling and decided to make a precautionary landing to remove it, he would not have flown as low as he did over the crags.

3. CONCLUSION

3.1. Findings

An analysis of the information available yields the following conclusions:

- The aircraft was airworthy and its documentation valid and in force.
- The pilot was qualified and had ample experience in transporting loads and people.
- The pilot had made 23 flights to the same place, almost all during the first few months of that year.
- That day he had made a previous flight and then made an initial transportation flight from the base to the staging area (next to the Incles Bridge).
- A third individual unhooked the load from the sling.
- This individual had worked previously with the pilot and the mechanic but was not qualified for this duty.
- The counterweight that is added to the sling to keep it from swinging during the flight and impacting parts of the helicopter was attached to the load side instead of being attached to the sling.
- The system utilized to attach the load to the sling (safety hook) is the same that is used on the load-counterweight ensemble.
- Various eyewitnesses along the helicopter's flight path agreed that it was flying unusually low considering the hanging sling, though none of them noticed anything abnormal about its flight path.
- Evidence was found indicating that the bottom of the sling had fouled a tree branch.
- No evidence was found to suggest a malfunction or mechanical failure of the aircraft.
- Neither the pilot nor the mechanic are believed to have been aware that the sling was attached to the hook.

3.2. Causes

The accident took place as the result of making a flight to ferry operators with the load sling left attached to the helicopter unbeknownst to the crew. This is why the flight was made at such a low altitude and high speed in comparison to those specified for operating with a sling. Under these conditions, when the helicopter flew over the crags, the sling fouled the branches of a pine tree, causing the helicopter to become unstable before crashing to the ground.

Contributing to the accident is the fact that the pilot and mechanic delegated the task of unhooking the load to an individual who, though used to doing it, was not specifically trained to do so, and then not checking that it had been properly done.

4. SAFETY RECOMMENDATIONS

The improper unhooking, as well as the failure to check that the sling had been released, was crucial to conducting the flight with the sling attached. The investigation confirmed that there were no specifically-trained personnel on hand to unhook the load apart from the pilot and the mechanic, and that no specific procedures governed the actions of the individual performing that task. The investigation also revealed that the operator was specifically working on developing just such a procedure, though it had not been implemented yet. As a result, the following safety recommendation is issued:

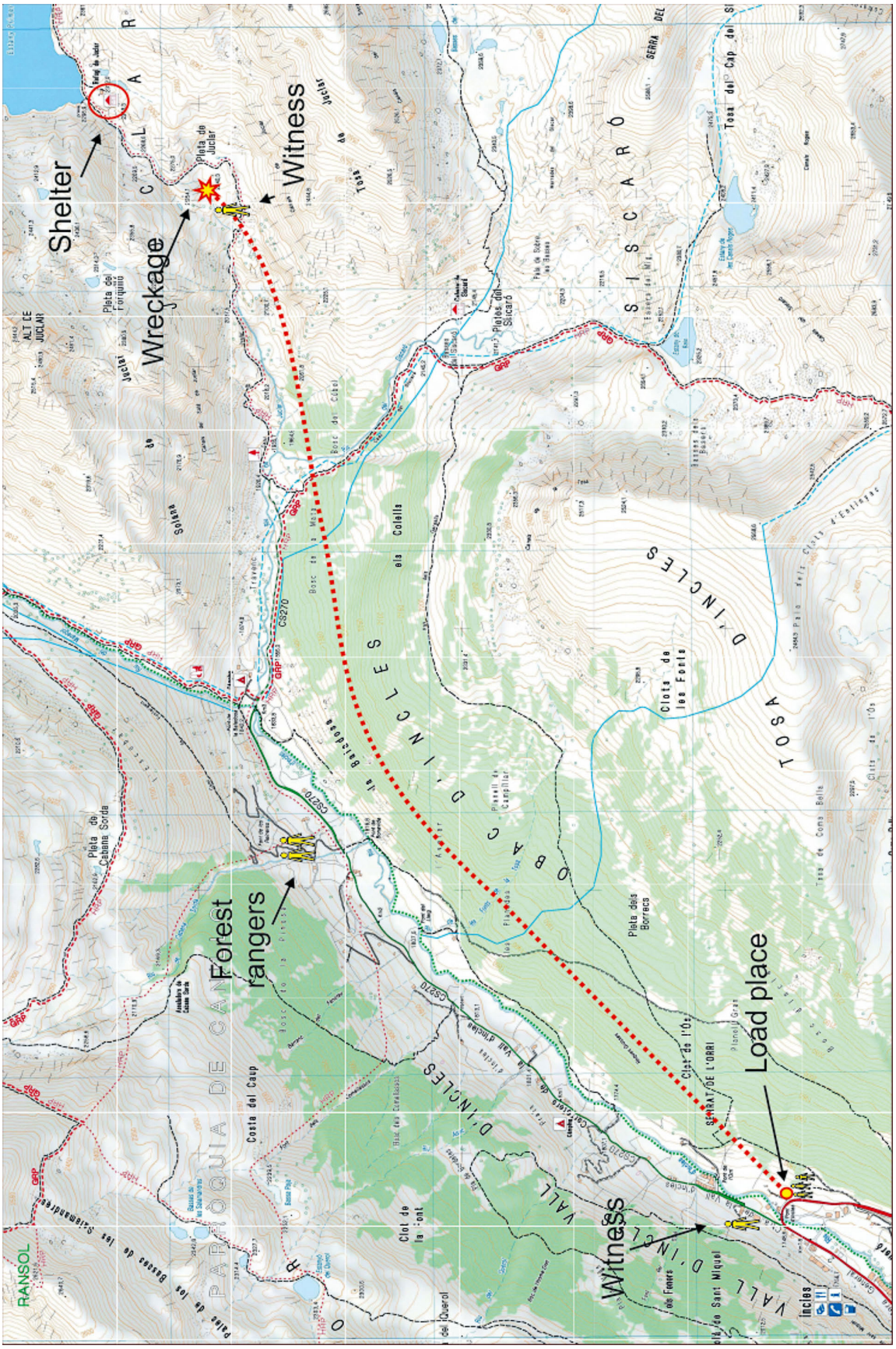
REC 48/13. It is recommended that the operator, CAT HELICOPTERS/HELIAND, implement the procedures it has been developing involving the transportation of external loads as concerns their handling and hooking by qualified personnel, and a subsequent check by the pilot, including those aspects concerning the check of any element attached to the aircraft as well as the establishment of communications between personnel on the ground and in the aircraft.

The flight being made was one to transport personnel, though with the aircraft remaining configured to carry an external load. This was due to the change from one operation to a completely different one without checking the new configuration required by the aircraft. The flight was made at a lower altitude and higher speed, which made it easier for the sling to foul a tree branch. As a result, the following safety recommendation is issued:

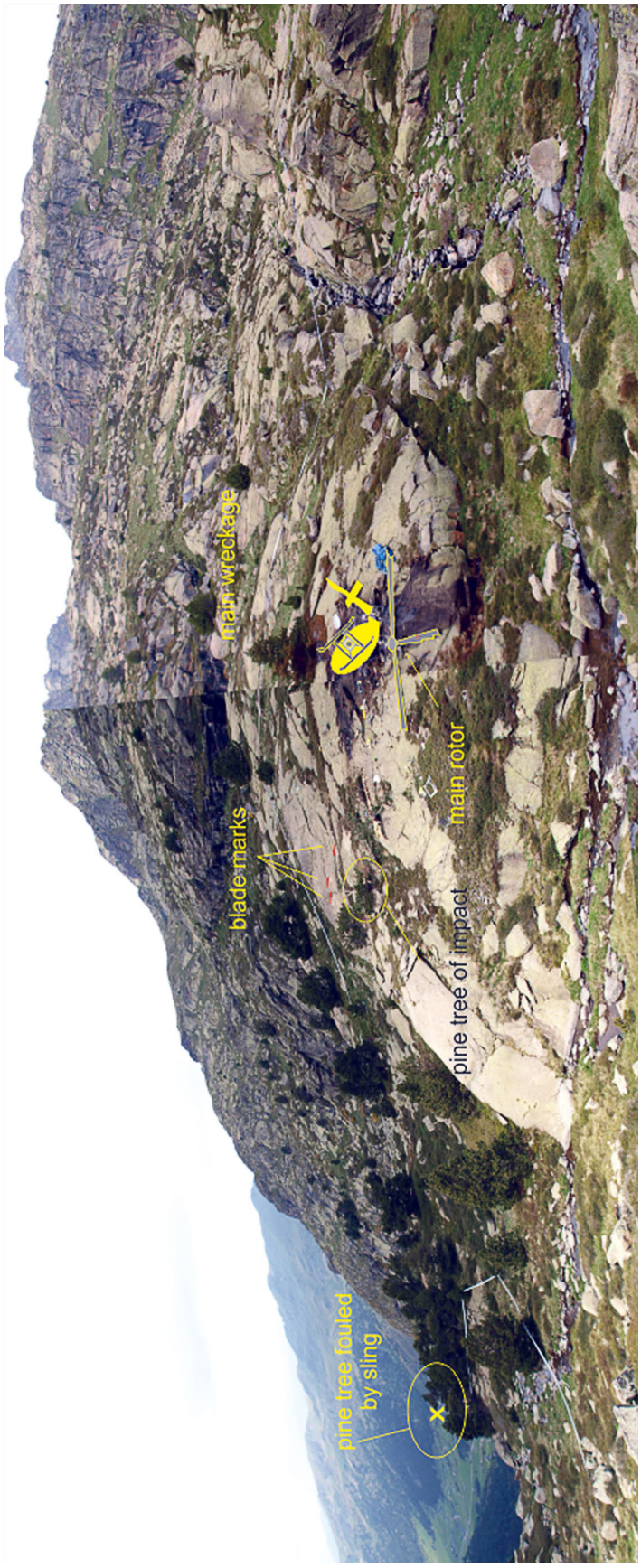
REC 49/13. It is recommended that the operator, CAT HELICOPTERS/HELIAND, establish independent checklists and a specific briefing (with an associated procedure) so that, whenever a change in the type of operation is made that requires changing to a configuration that is completely new from that previously established, said configuration is verified to be appropriate.

APPENDICES

APPENDIX A
Flight path taken by the helicopter


Shelter
Witness
Wreckage
Forest rangers
Load place
Witness

APPENDIX A
Debris field


main wreckage
blade-marks
main rotor
pine tree of impact
pine tree fouled
by sling