Technical report
A-035/2022

Accident on 20 July 2022, involving a Eurocopter AS-350-B3 aircraft, registration EC-LBU, operated by Pegasus Aviación, in the municipality of Tortuero, Guadalajara (Spain)

GOBIERNO DE ESPAÑA
MINISTERIO DE TRANSPORTES Y MOVILIDAD SOSTENIBLE
UNDERSECRETARIAT
CIVIL AVIATION ACCIDENT AND INCIDENT INVESTIGATION COMMISSION

Notice

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

In accordance with the provisions in Article 5.4.1 of Annexe 13 of the International Civil Aviation Convention; and with Articles 5.5 of Regulation (EU) No 996/2010 of the European Parliament and of the Council of 20 October 2010; Article 15 of Law 21/2003 on Air Safety; and Articles 1, 4 and 21.2 of RD 389/1998, this investigation is exclusively of a technical nature, and its objective is the prevention of future aviation accidents and incidents by issuing, if necessary, safety recommendations to prevent their recurrence. The investigation is not intended to attribute any blame or liability, nor to prejudge any decisions that may be taken by the judicial authorities. Therefore, and according to the laws specified above, the investigation was carried out using procedures not necessarily subject to the guarantees and rights by which evidence should be governed in a judicial process.

Consequently, the use of this report for any purpose other than the prevention of future accidents may lead to erroneous conclusions or interpretations.

Comisión de Investigación de Accidentes e Incidentes de Aviación Civil – CIAIAC

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ABBREVIATIONS

° ‘ “	Sexagesimal degrees, minutes and seconds
°C	Degrees Celsius
ACT	Hours of flight experience in relevant activities
AEMET	State Meteorological Agency
AESA	Spain’s National Aviation Safety Agency
ALF	After the last flight of the day
ASC	Hours of flight experience in similar aircraft
BFF	Before the first flight of the day
SOE	Special Operator Certificate
CPL(H)	Commercial helicopter pilot license
EASA	European Aviation Safety Agency
ELT	Emergency location transmitter
FADEC	Full Authority Digital Engine Control
FH	Flight hours
FLI	First Limit Indicator
ft	Feet
h	Hours
kg	Kilograms
km	Kilometres
km/h	Kilometres per hour
kt	Knots
kW	Kilowatts
l, l/h	Litres, Litres/hour
LAPL	Light aircraft pilot license
FF	Firefighting operations
m	Metres
mm	Millimetres
m/s	Metres/second
m^2	Metres squared
OM	Operations Manual
MSM	Master Service Manual
MTOP	Maximum take-off power
s/n	Serial number
N	North

Nf	Free power turbine speed
Ng	Engine gas generator speed
NR	Rotation speed of the main rotor
W	West
PIC	Pilot-in-command
PICmin	Minimum previous experience in flight hours as pilot-in-command
SAR	Search and rescue service
SOP	Standard operating procedures
SP	Single Pilot
TA	Visual inspection of the aircraft during turn-around
UTC	Coordinated universal time
VEMD	Vehicle and Engine Multifunction Display
VFR	Visual flight rules
VHF	Very high frequency (30 to 300 MHz)

Technical report

A-035/2022

Owner:	Importaciones Carreira
Operator:	Pegasus Aviación
Aircraft:	Eurocopter AS-350-B3, registration EC-LBU, s/n: 4780
Date and time of accident:	Wednesday 20/July/2022, 08:40 UTC
Site of the accident:	Sierra Norte de Guadalajara Natural Park, municipality of Tortuero – Guadalajara (Spain)
Persons on board:	1 (pilot)
Type of operation:	Aerial works – Commercial – Firefighting
Phase of flight:	Vertical take-off
Flight rules:	VFR
Date of approval:	28/JUNE/2023

Synopsis

Summary:

On Wednesday, 20 July 2022, the AS-350-B3 helicopter, registration EC-LBU, struck an electrified fence while performing a take-off manoeuvre.

The aircraft was on a firefighting (LCI) mission in the Sierra Norte Natural Park in the municipality of Tortuero, province of Guadalajara, and was taking off after leaving a brigade on the ground in a rugged area near the fire.

The pilot landed the aircraft immediately and was unharmed. The helicopter sustained significant damage to its main and tail rotors and the horizontal stabiliser.

The investigation has revealed the probable cause of the accident to be a manoeuvre that did not comply with the limits of the area chosen for the operation, which caused the tail rotor to hit the aerial wire of an electrified fence and pull out its ground support rod, which in turn impacted the fuselage and the main rotor.

As a result of the damage to the helicopter, the pilot had to make an emergency landing on the road from which he had taken off.

1. THE FACTS OF THE INCIDENT

1.1. Overview of the accident

On 20 July 2022, at 08:00 UTC, the Eurocopter AS-350-B3 2B1 aircraft, registration EC-LBU, operated by Pegasus Aviación, took off from the Hiendelaencina-Las Minas Aerodrome and firefighting base in the province of Guadalajara, also known as Villares de Jadraque Aerodrome.

The two AS-350-B3 helicopters stationed at the base, which worked in formation, were mobilised to respond to a forest fire about 10 miles from the base in Valdepeñas de la Sierra.

Both helicopters were sent to the fire, where several aerial resources were already operating, to transport firefighters and carry helibuckets to drop water on the fire.

After receiving clearance to approach and offload the firefighters, they circled to reconnoitre the terrain and assess which area to land in.

Helicopter 1 of the formation decided to land in an area that was only big enough for one helicopter, which meant they had to approach and land one after the other. The EC-LBU helicopter was acting as helicopter 2 in the formation, and while waiting for helicopter 1 to unload the firefighters, its pilot, according to his testimony, noticed that he was in the flight path of the carousel of helicopters deploying water, so he decided to move out of the way and look for another landing point.

Photograph 1: Aircraft EC-LBU at the incident site

The area chosen to disembark the forest fire squad was a road that was, according to the information provided by the pilot, in an unconfined space, with a headwind and possible downhill escape routes in case of any complications. It was in a mountainous area, with a downward slope above the road and another slope on the other side of the road at about 255º W. According to the pilot, as the road was covered in a thick layer of dust, he decided to "sweep" it from a high hover.

After the high hover, the helicopter was able to perform a standard landing, setting down safely in the middle of the road and parallel to it, observing that there was an electrified fence consisting of a metal wire attached to iron rods on both sides.

The firefighters disembarked without incident and deployed the helicopter bucket for subsequent water loading.

According to his statement, the pilot then prepared to ascend to a hover, making minor pedal adjustments to take off again. At that moment, he noticed a strong vibration in the flight controls that made it difficult to control the hover manoeuvre, so he immediately decided to perform what he called an autorotation from a hover, setting the helicopter back down on the road.
Automatically, according to the pilot, he lowered the collective pitch and cut the throttle to land the helicopter safely as soon as possible.

On exiting the helicopter unharmed and unaided, he saw that the electrified fence wire had caught on the tail rotor and dragged the metal rod out of the ground. The mission lasted for a total of 38' and 33' of flight time.

1.2. Injuries to persons

Injuries	Crew	Passengers	Total in the aircraft	Others
Fatal	-	-	-	-
Serious	-	-	-	-
Minor	-	-	-	-
Unharmed	1	-	1	-
TOTAL	1	-	1	-

1.3. Damage to the aircraft

The aircraft sustained damage to its tail rotor, horizontal stabiliser and main rotor.

1.4. Other damages

Minor damages to the electrified fence.

1.5. Information about the personnel

1.5.1. Pilot

The 41-year-old pilot had a commercial helicopter pilot license, CPL(H), issued by Spain's National Aviation Safety Agency (AESA) on 15/01/2014 with the following ratings:

- Type rating AS-350/EC-130/SP single-pilot, valid until 31/10/2022,
- Type rating Bell 212/412/SP single-pilot, valid until 31/01/2023,

The pilot had a certificate of competency in firefighting operations with non-complex helicopters, valid until 30/05/2023, issued by the operator.

His medical certificate was valid until 10/11/2022 for Class 1 in commercial operations with a single pilot carrying passengers, until 10/05/2023 for Class 1 (general) and until 18/06/2023 for Class 2 and LAPL.

His total flight experience was 694:54 h, of which 96:34 h were in the type of aircraft involved in the accident (single-engine) and 561:20 h were in other twin-engine helicopter types such as the Hughes 269, BELL 412 and BELL 212.

As a pilot-in-command, he had 473:30 h of flight time, of which 356:31 h had been gained in firefighting activities during the 8 consecutive years since 2014.

In terms of recent activity, the day before the incident, he made 4 flights with a total duration of 7:51 h and 7 landings, starting the first flight at 09:05 h and ending his activity at 19:15 h. In the 5 days before the incident, he had flown every day, accruing 21:34 hours of flight time and 27 landings without incident.

His last type-specific recurrent training on the AS-350-B3 2B1 aircraft type and the last operator type-specific proficiency check were conducted on 03/05/2022 and lasted 1 h.

In regard to firefighting operations, the pilot's most recent training and proficiency check on the AS-350-B3 aircraft was conducted on 17/05/2022 during two flights with a total duration of 2:12 h. This training included practising vertical take-offs in confined and sloping areas.

1.6. Information about the aircraft

1.6.1. General information

The Airbus Helicopters AS-350-B3 2B1 aircraft, registration EC-LBU and s/n: 4780 is a light, single-engine helicopter built in 2009, with a capacity of up to six people, equipped with a

Turbomeca Arriel 2B1 turbine (MTOP[1] 557 Kw) s/n: 46275, whose avionics include an electronic VEMD[2], FLI[3] and FADEC[4].

I. Main details

- Empty weight: 1,372.56 kg.
- Maximum take-off weight: 2,250 kg.
- Dimensions
  - Diameter of the main rotor: 10.69 m (3 blades)
  - Diameter of the tail rotor: 1.86 m (2 blades)
  - Total length: 12.94 m
  - Fuselage length: 10.93 m
  - Width: 1.87 m
  - Total height: 3.14 m
- Performance:
  - Never-exceed speed: 155 kt
  - Cruise speed: 140 kt
- Main rotor: semi-rigid with a three-bladed *Starflex* rotor head.
- Main rotor blades made of composite materials.
- Single hydraulic system.
- Tail rotor: flexible see-saw type[5] made mainly from composite materials.

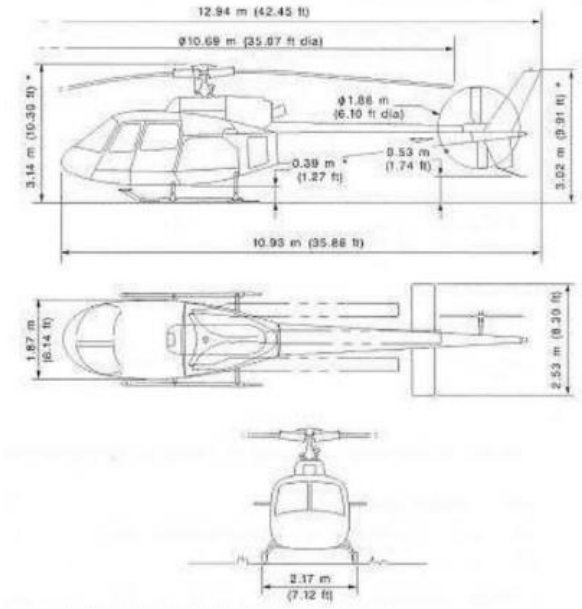


Figure 1: Aircraft AS-350-B3

The pilot refuelled at the start of the mission with 357 litres of fuel.

At the end of the flight, there were 270 litres remaining. Consequently, taking into account the weight of the pilot as the only occupant at the time of the accident and the weight of the aircraft and its equipment, the aircraft's total weight during the operation was 1,817.56 kg, which is below the maximum allowed, and therefore his actions were not affected by any limitations.

[1] MTOP: Maximum take-off power.
[2] VEMD: Vehicle and Engine Multifunction Display - A system consisting of two LCD multifunction displays used in flight mode to monitor the engine and helicopter, one on each display, optimising and calculating the mission parameters for the pilot.
[3] FLI: First Limit Indicator.
[4] FADEC: Full Authority Digital Engine Control.
[5] Flexible See-saw-type tail rotor.

II. Instrument panel

Photograph 2. Instrument panel of the incident aircraft

III. Operational procedures

The following operating procedures from the aircraft's flight manual are relevant to the investigation.

Normal procedures

- **Take-off**

For take-off, gradually raise the collective pitch and maintain a hover, facing into the wind, at a height of about 5 ft.

Check that the transmission and engine monitoring instruments are within normal operating values.

To transition from the hover, increase speed without increasing power demand and do not climb until the speed is 40 kt.

- **Landing**

From a hover, reduce the collective pitch gradually until touchdown is achieved; it can then be cancelled completely.

If landing on a slope, the cyclic control lever must be returned to neutral before setting the collective pitch to its lowest position.

Emergency procedures

- **Tail rotor drive failure**

A failure of the tail rotor in powered flight results in a yaw movement to the left; the extent of this rotation will depend on the power and speed setting at the time of failure.

In the event of tail rotor failure in stationary flight or at low speed in an IGE situation, the throttle should be moved to the idle position and the touchdown cushioned by pulling the collective pitch lever.

Standard operating procedures (SOP)

The landing site selection criteria are defined in the operator's OM, PART C, in the SOPs for:

- Operations on non-prepared landing sites.
- Operations in mountainous areas.

- **SOP for operations on non-prepared landing sites**

This procedure includes the following sections:

(A) NATURE AND COMPLEXITY OF THE OPERATION
(B) AIRCRAFT EQUIPMENT
(C) FLIGHT CREW
(D) OTHER PERSONNEL
    Operational personnel
    Additional specialist personnel
    Additional personnel
    Ground support personnel
(E) PERFORMANCE
(F) STANDARD PROCEDURES
    (1) Flight techniques
    (2) Ground procedures
(G) EMERGENCY PROCEDURES
    (1) Operating procedures
    (2) Ground procedures

Section F of the SOP includes instructions for selecting a landing point at an unprepared site, detailing the requirements for speed and height control, the types of reconnaissance to be conducted, manoeuvres in the confined area and the different types of take-offs.

- **SOP for mountainous areas**

This procedure includes the following sections:

(A) NATURE AND COMPLEXITY OF THE OPERATION
    (1) Nature of the activity
    (2) Complexity of the operation
    (3) Geographical area
    (4) Evaluation and assessment of the risk involved in the activity
(B) AIRCRAFT EQUIPMENT
    (1) Aircraft
    (2) Equipment
(C) FLIGHT CREW
    (1) Composition of the flight crew
    (2) Requirements
    (3) Training and experience
(D) OTHER PERSONNEL
    Operational personnel
    Additional specialist personnel
    Additional personnel
    Ground support personnel
(E) PERFORMANCE
(F) STANDARD PROCEDURES
    (1) Flight techniques
    (2) Ground procedures
(G) EMERGENCY PROCEDURES
    (1) Operating procedures
    (2) Ground procedures

Section F of the SOP includes instructions for landing point selection in mountainous areas, detailing the requirements for speed, altitude and flight attitude control, the flight line and types of reconnaissance to be performed, and approach and take-off manoeuvres in different types of mountainous terrain, peaks and valleys.

1.6.2. Maintenance information

The aircraft was built in 2009 with serial number: 4780. An EASA-certified maintenance centre maintained the helicopter according to the approved maintenance programme ref: CVO-PM-AS350B3-03, ed.1, rev.14 of 05/05/2022.

According to this maintenance programme, periodic airframe inspections of varying scope and depth must be performed daily, every 10 FH or 7 days, 150 FH or 12 months, 600 FH or 24 months, and 1,200 FH or 48 months (whichever occurs first); and engine inspections are to be performed daily, every 15, 25, 30, 50, 150, 300, 600 FH and every 15 years.

In addition, following an operational incident or in unusual weather conditions, the non-scheduled inspections detailed in the MSM[6] must be carried out.

The daily inspections include:
• BFF: Before the first flight of the day
• TA: Turn around
• ALF: After the last flight of the day

The last three preventive maintenance inspections performed on the helicopter were as follows:

- 13/07/2022: BFF, ALF and the G04 group tasks.
- 18/07/2022: BFF, ALF, the G04 group tasks and the 25 FH scheduled inspection.
- 19/07/2022 BFF, ALF, the tasks in group G04 and the 25, 30 and 100 FH periodic inspections completing the set of tasks in groups G05, G06 and G08, respectively.

And the last engine inspections:

- 06/07/2022: 30 FH inspection.
- 07/07/2022: 25 FH inspection.
- 20/07/2022: BFF, TA and 15 FH inspection.

The most recent corrective maintenance inspections were performed on 14 and 15/07/2022 on the main rotor.

The aircraft was compliant with the applicable manufacturer's service bulletins and airworthiness directives, the most recent of which was implemented on 30/06/2022.

At the time of the accident, the helicopter had a cumulative record of 2308:00 FH and 13,587 landings, and the engine had 3501:00 FH.

The day before the incident, on 19/07/2022, the aircraft made 4 flights of about 2 h each, with the first flight starting at 9:05 h and the last one ending at 19:15 h. On 18/07/2022, it made 4 flights lasting between 1:20 and 2 h each, with the first flight starting at 10:05 h and the last one ending at 19:41 h.

None of these flights reported any type of aircraft failure or incident.

[6] MSM: *Master Service* Manual

1.6.3. Airworthiness status

According to AESA's record of active registrations, the aircraft with serial number 4780 and registration EC-LBU was registered in the name of the current owner on 29/12/2020, with registration number 8641. The aircraft operator and lessor had the necessary authorisations to carry out aerial firefighting operations.

The aircraft had Airworthiness Certificate No. 6921, issued by AESA on 01/07/2009 with indefinite validity, in the "Small Helicopter" category with designation as a "Eurocopter AS-350-B3". It also had an airworthiness review certificate with ref.: ES.ARC-LBU-005, valid until 27/09/2022 and issued when the aircraft had 2228 flight hours.

1.7. Meteorological information

We consulted AEMET for the meteorological data at the time and place of the accident. As there was no station at the site itself, two alternative weather stations were selected: the one at the El Vado reservoir, located 9.5 km from the accident site, and the one at Buitrago del Lozoya, located 20.9 km away. The data recorded at both stations showed light winds with low-speed gusts, temperatures around 27ºC, relative humidity between 30 and 40% and no records of any relevant meteorological phenomena. As a result, it has been concluded that the operation was not affected by adverse meteorological conditions.

The pilot checked the meteorological information and confirmed that no NOTAMs affecting the area of the flight on the date and time of the accident had been issued.

1.8. Aids to navigation

The flight was operating under visual flight rules (VFR).

1.9. Communications

The aircraft was equipped with a Garmin GNS430w VHF COMM 1 system, a BENDIX KING KX 165 A VHF COMM 2 system, and a Garmin GTX 330 transponder. All three systems were working correctly and are not relevant to the causes of the incident.

The coordination and communications between the air resources during the firefighting (LCI) operation were carried out in line with SOP-LCI by the Command Centre, the Firefighting Commander and the Air Resources Coordinator, taking into account that the aircraft involved in the incident was not the first to arrive at the fire and that the Fire Flight Area was continually changing as the fire evolved. The pilot in radio contact with the Air Resources Coordinator must be informed, at all times, about the standby circuit, the work circuit, clearance to enter the fire operations area, the risks/hazards of the area, the loading area, the brigade disembarkation area, the command to drop water and finally, once the mission has been completed, the departure from the fire area.

This procedure was followed by establishing the communications necessary to coordinate with the other aerial resources involved in the operation.

1.10. Information about the accident site

The firefighting operation was mobilised in response to a forest fire that started in Valdepeñas de la Sierra and spread to the municipality of Tortuero in the Sierra Norte de Guadalajara Natural Park (Spain).

Given that several air resources were operating in the area, there was only room for one helicopter to land in the zone designated to offload the firefighters, and the aircraft involved in the incident was acting as point 2 in the formation. When the pilot realised that he was in the path of the carousel of helicopters unloading water, he decided to move away and assess another landing point.

The area chosen was a forest road in an unconfined area, with headwind and a possible escape route down the hillside in case of an emergency. According to the pilot's statement, these were the criteria used for selection.

It was a mountainous zone, with a downhill slope above a forest road about 3 m wide and a slope on the other side of the road, bearing 255º W (photograph 3).

Photograph 3. Descending slope from the incident site

Photograph 4. Position of the aircraft above the descending slope

The road was bordered on both sides by an electrified fence of the type used to contain livestock.

The accident occurred when the helicopter took off again. The aircraft struck the aerial wire of the electrified fence and came to rest at 40° 56' 29.5" N; 3° 22' 51.3" W, with its longitudinal axis parallel to the axis of the forest road and with a north-easterly bearing.

The electrified fence consisted of an aerial wire attached to solid steel rods measuring 8 mm in diameter and 1.5 m long.

The rods were rusty, which made them difficult to see. They were approximately 6 m apart, with one end inserted vertically about 40 cm into the ground, keeping the tension on the wire.

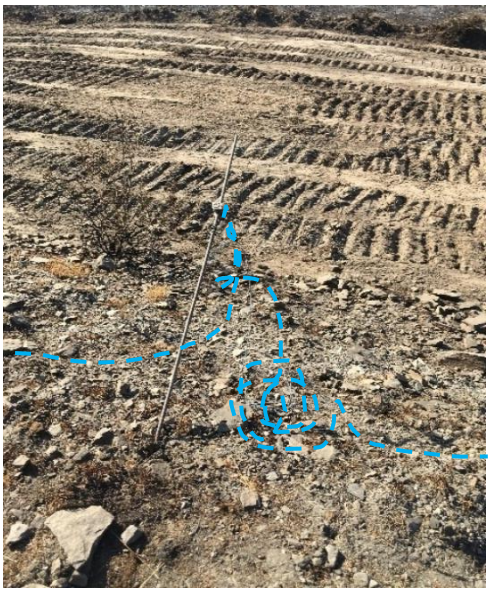
The wire consisted of a thin strand of braided blue nylon and steel, approximately 3 mm in diameter.

Photograph 6 shows the rod found 6 to 7 m in front of the aircraft with no traces of wire or the retaining insulator.

Photographs 7 and 8 show two rods with their conductor wire severed at one end still attached to the circular retaining insulator at the other. Given that it is hard to see in both photographs, the position of the wire has been highlighted in blue.

Photograph 5. Position of the aircraft on the forest road

Photograph 6. Detached electrified fence rod



Photograph 7. Electrified fence rod bent after the accident

Photograph 8. Electrified fence rod bent after the accident, with the end of the electrified wire

1.11. Flight recorders

The aircraft was not equipped with a flight data recorder or cockpit voice recorder, as the current aviation regulations do not require a recorder to be carried on this aircraft type. However, it did have a VEMD and fleet tracking system.

1.11.1. VEMD (Vehicle and engine management display)

The helicopter had a vehicle and engine management monitoring system, consisting of a multifunction display in the central part of the instrument panel, which shows the engine and aircraft parameters.

This system records any exceedances that may have occurred in the parameters it monitors, such as main rotor speed, torque, compressor and free turbine rotation speeds, etc.

The data corresponding to the accident flight was downloaded, confirming that no exceedance had been recorded. The records showed a flight duration of 38', recording engine cycles with the following Ng values: 1.18 and Nf: 0.50.

1.11.2. Fleet tracking system

The helicopter was equipped with a fleet tracking system from which the flight data for the incident mission were retrieved. The following parameters of interest to the investigation were recorded and analysed: Time - Latitude - Longitude - Altitude - Trace - Speed - Type of event.

The data was recorded at 15" intervals between 10:01:26 h (time of startup) and 10:40:03 h (time of shutdown) as per the trajectory shown in figure 2.

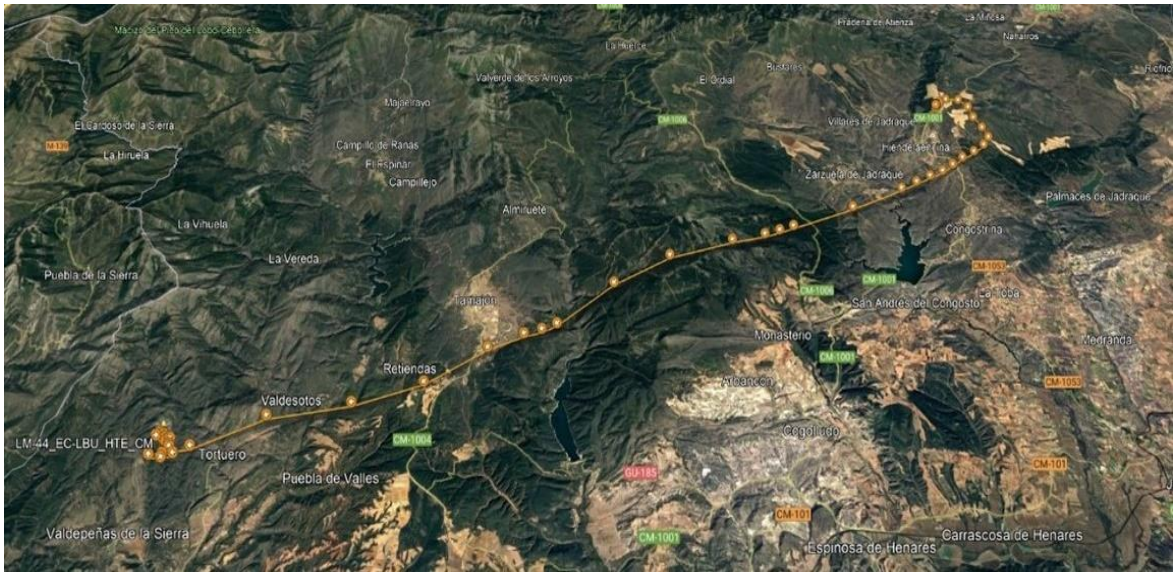


Figure 2: Trajectory of the incident flight

From the moment the helicopter landed (altitude 1012 m) to disembark the firefighters, prepare the helibucket for use and proceed to take off again to continue the firefighting mission, 4'15" elapsed (from 10:33:15 h to 10:37:30 h). At that point it climbed 5 m with a heading of 112º and a speed of 1 km/h (phase I of figure 3).

At 15" (10:38:00 h), it climbed 3 m further, rotating anticlockwise to 106º (phase II of figure 3), and then descended over the next 15" (10:38:15 h), rotating clockwise to 233º (phase III of figure 3).

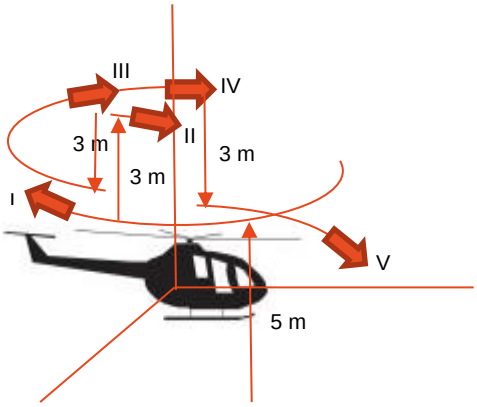


Figure 3: Changes in heading and altitude in the final part of the flight

At 10:38:30 h, maintaining an altitude of 1017 m, it continued rotating to a heading of 272º and 0 km/h (phase IV of figure 3), returning to its initial heading of 0º (phase V of figure 3) at 10:38:45 h descending 3 m (altitude 1014 m).

Maintaining that heading, it reached an altitude of 1009 m and at 10:40:03 h, the aircraft came to a complete stop on the ground.

This flight, lasting a total of 2' 33" and comprising phases I to V as described above, is the flight in which the impact with the electrified fence took place, the trajectory of which can be seen in figures 4 and 5.

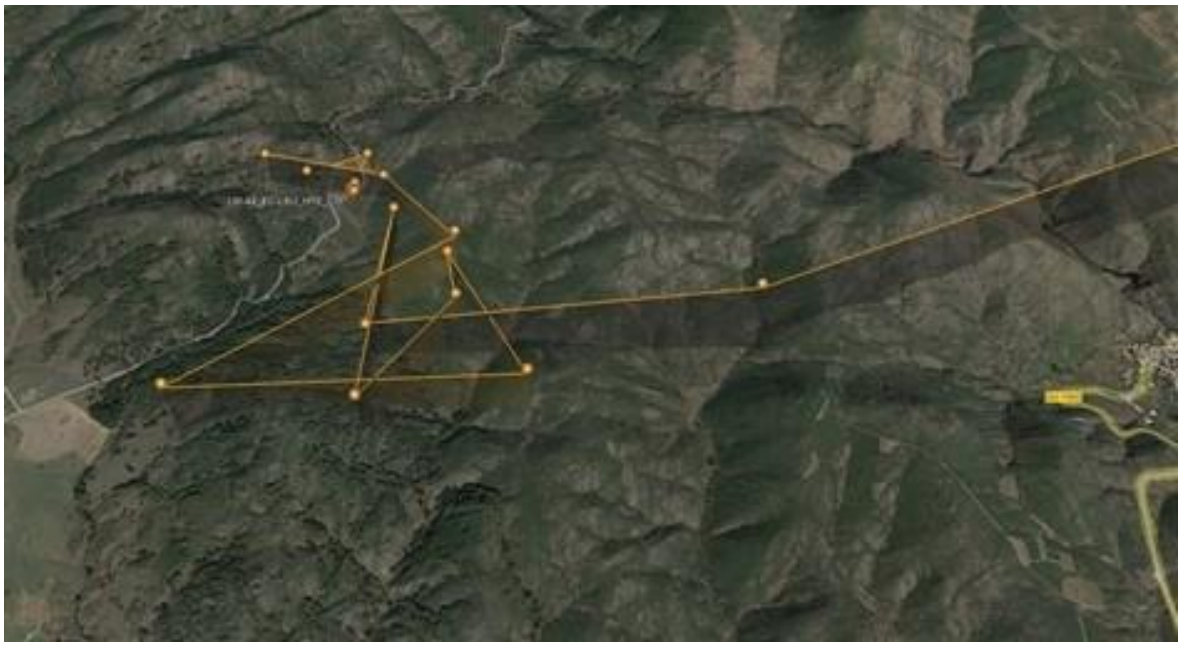


Figure 4: Final phase of the trajectory of the incident flight

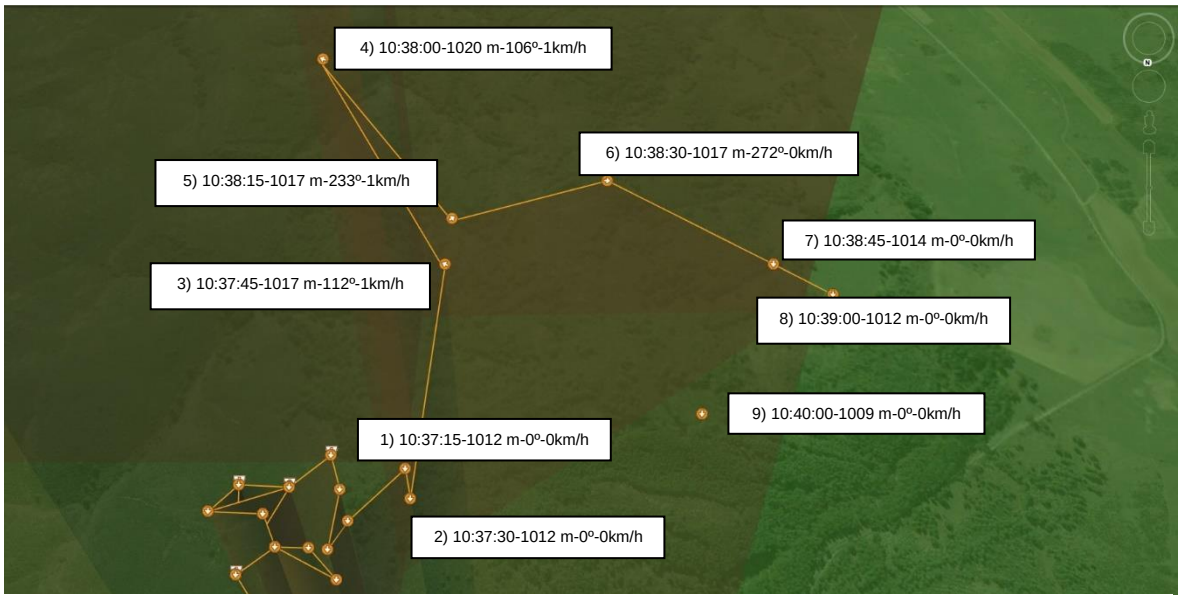


Figure 5: Data recorded during the final part of the incident flight

1.12. Information about the damage to the aircraft and the area of the accident

When the pilot took off to continue his mission after disembarking the firefighters, the aircraft's tail cone made a sideways movement while hovering, which caused the impact with the aerial wire of the electrified fence. On exiting the aircraft, the pilot could see that the electrified fence wire had wrapped around the tail rotor, dragging one of its supporting ground rods, which was found 6 or 7 metres in front of the aircraft, with it.

The aircraft came to a standstill at almost exactly the same spot on the forest road from which it had taken off and did not leave any marks on the ground. The only debris visible around the helicopter were remnants of material from the blades.

There were marks on both the tail rotor and the main rotor from the impact with the braided wire and the metal ground rod that had been supporting it.

The damage identified on the helicopter after the event was as follows:

1. Tail rotor

The tail rotor was destroyed with mechanical damage to the tail rotor yoke.

- Damaged tail rotor blades.
- Tail rotor drive system: damage to the fairing covering the gearbox, with loose tail cone attachment bolts.

Detached rivets with large cracks in the structural supports where the gearbox is installed.

- Damaged quill shaft or input coupling, separating the gears from the gearbox, bending the flexible couplings linking the tail rotor section to the TGB (tail gearbox) and damaging the pitch change connection.

Photograph 9: Damaged tail rotor blades

Photograph 10: Damage to the tail rotor drive system

Photograph 11: Damage to tail rotor input quill and flexible coupling

Tail rotor drive shaft: The bearings supporting the shaft are all out of their housings. The shaft is visibly displaced forwards due to the rupture of the TGB. The fairings covering the section have internal marks in the area of the flexible couplings.

- The flexible couplings connecting the engine module 5 (reduction gearbox) to the bent tail shaft.

Photograph 12: Gears on tail rotor drive shaft

Photograph 13: Damaged flexible couplings

2. Horizontal stabiliser

Breakage on trailing edge.

Photograph 14: Damage to horizontal stabiliser

3. Tail cone

Major damage to both the primary structure and the skin from the horizontal stabiliser area rearwards. Severe dents and cracks. VHF antenna damaged.

Photograph 15: Damage to the tail cone

4. Vertical stabiliser

Minor dents on the underside leading edge of the vertical stabiliser on the tail rotor side.

5. Main rotor blades

Damage to two of the three main rotor blades, the yellow blade and the blue blade. A dent on the leading edge of the blue blade, with damage to the main beam. Loss of material from the tip of the yellow blade.

Photograph 16: Damage to the main rotor blades

1.13. Medical and pathological information

No evidence was found to suggest the pilot's performance was affected by physiological or disabling factors.

1.14. Fire

No fire broke out on the aircraft.

1.15. Survival aspects

The helicopter's cabin remained structurally intact and the safety belts functioned effectively.

The pilot was unharmed and able to exit the aircraft without assistance.

1.16. Tests and research

No special tests were required.

1.17. Organisational and management information

The operator had a valid Special Operator Certificate (SOC[7]), issued on 27/08/2021 by EASA, authorising aerial operations for commercial firefighting and search and rescue purposes. In addition, it had EASA Part-145 approval as a maintenance organisation for the accident aircraft, both for base and line maintenance.

The activity undertaken during the accident flight was firefighting, which is regulated by Royal Decree 750/2014 of 5 September, which also approves the rules applicable to said aerial activities, incorporated as Annexes I to IV.

Part A of the current operations manual for FF and SAR (OM-A), ed.3 rev.8, details the requirements of the aforementioned royal decree, particularly those relating to the experience of the pilot-in-command, as set out in TAE.ORO.FC.LCI.212 for FF operations[8]:

	PIC	ACT	ASC	PICmin
Helicopter				
Observation and patrolling	200	—	—	—
Coordination	300	30	—	200
Deployment of water and transfer of additional specialist personnel	500	50	100	400

Figure 6: Firefighting experience requirements

With regard to recent experience, the operator's OM-A states that pilots may not operate an aircraft:

- as pilot-in-command, unless they have carried out, within the preceding 90 days, at least 3 take-offs, approaches and landings in an aircraft of the same type or class or in a simulator representing that type or class. The 3 take-offs and landings must be performed in multi-pilot or single-pilot operations, depending on the pilot's ratings, and
- as pilot-in-command in FF operations requiring water deployment unless they have conducted at least 3 water loading and unloading operations with an aircraft of the same type or class or simulator representing that type or class within the preceding 90 days.

For firefighting operations, the operator's OM states that a pilot may only be designated as highly experienced if they hold the type rating for the aircraft they use to carry out their duties and that they must have a minimum of 600 hours as PIC, of which 100 hours must have been accrued in firefighting activity, and 50 hours in the relevant aircraft type. In addition, they must be able to demonstrate one of the following forms of experience:

- more than 5 forest fire campaigns;

[7] SOC: Special Operator Certificate

[8] ACT: hours of flight experience in relevant activities

ASC: hours of flight experience in similar aircraft

PICmin: minimum previous experience in flight hours as pilot-in-command

- more than 3 forest fire campaigns, including the two most recent ones;
- experience as an agro-forestry instructor.

With regard to flight time limitations and rest breaks to ensure safe operations, the OM establishes that helicopter flights in firefighting operations shall not last longer than 2 h with intermediate stops of at least 40' for every 2 h of flight, and for flights of less than 2 h, a 20' intermediate stop for every hour of flight or 10', whichever is greater.

Any period of physical presence must be preceded by a rest period of at least 10.5 hours.

The pilot-in-command during the incident flight complied with the experience requirements established for firefighting operations, as well as the required rest periods and flight limitations. Furthermore, the operation was conducted in compliance with the limitations included in paragraph 1.2 of the OM Part B for the AS350-B3 helicopter type and in accordance with standard operating procedures.

In regard to the specific training provided to the PIC on the aircraft and operation type involved in the incident, as per Part D of the OM, the organisation had additional approvals allowing it to conduct recurrent type training and proficiency checks for firefighting operations. Specifically, the pilot involved in the event had received both two months before the incident, so the OM requirements had been met.

The organisation also had standard, non-standard and emergency procedures for firefighting operations in place, in line with OM-B 12.3 and SOP-LCI-H Ed.: 03; Rev.: 02 dated 20/08/2021, which covers the following aspects relevant to the investigation:

- The criteria for selecting set-down points for operations in unprepared and/or mountainous landing sites.
- The complexity of these types of operations requires that special consideration be given to the unique conditions that the flights may entail, such as:
    - low altitude
    - low speed
    - flying close to the operational limits of the helicopter
    - hostile areas with medium-high air traffic density, as several aerial resources of different categories may converge in small spaces
    - the need to land nearby to unload crews
    - the need for a water collection point in the vicinity
    - low visibility in some areas due to smoke
    - turbulence caused by the fire itself

Furthermore, according to the OM, if the pilot in command of an aircraft is aware that they are not the first aircraft to arrive at the fire, they must act bearing in mind that a Fire Flight Area of a radius proportional to the magnitude of the fire will have been established around the fire, which will change depending on how it evolves. This will include the establishment of initial contact rings with the incoming aerial resources, the approach to the area, the fire operations zone, the manoeuvring zone for unloading, notifications between the various

resources, surveillance and identification of the fire area to find the most suitable landing zone for the firefighters to disembark, standby circuits, risks and dangers due to the presence of cables or low or high voltage pylons, etc.

1.18. Additional information

N/A.

1.19. Special investigation techniques

N/A.

2. ANALYSIS

2.1. Analysis of the meteorological conditions

The weather conditions in the area and around the time of the event were not limiting for the flight; the wind was not significant, the gusts were of low intensity and no relevant meteorological phenomena were observed.

The only aspect to consider is that visibility was limited by the smoke and suspended dust on the forest road caused by the fire and the aerial resources in the area, including the operation of the aircraft involved in the incident.

The fact that the aircraft landed on a slope on the hillside to facilitate the disembarkation of the firefighters and their access to the fire further uphill placed the helicopter in an area of turbulence caused by the orography of the terrain and the high temperatures produced by the fire itself.

Although no adverse weather phenomena were recorded, the specific conditions produced by the fire resulted in phenomena that could not be recorded but affected the firefighting flight. Specifically, the area's low visibility and local turbulence may have contributed to the control issues during take-off, causing the helicopter to rotate, which resulted in the tail rotor impacting the aerial wire of the electrified fence.

2.2. Analysis of the aircraft wreckage

Following the inspection of the aircraft at the accident site and the inspection carried out by the operator at its maintenance facilities, we concluded that the significant damage to the helicopter was consistent with the testimonies provided and the evidence found.

The helicopter was adequately maintained and up to date with its regular inspections and the implementation of service bulletins and manufacturer directives. Therefore, we do not believe the aircraft was affected by an operational failure that could have contributed to the accident.

There were no marks on the ground at the accident site, except for those identified as a result of the damage to the electrified fence and the discovery, in the vicinity of the aircraft, of small pieces of material from the tail and main rotor blades.

After feeling a strong vibration in the flight controls that made it difficult to control the hover manoeuvre, the pilot repositioned the helicopter over the road in a controlled manner without producing any impact or sudden contact with the terrain.

It was noted that the aerial wire of the electrified fence bordering the road on its downhill side, to the pilot's left, was severed. Two of the metal retaining rods were found tilted and bent towards the ground, with the wire severed and stretched at one end on both rods. Another of the rods was found about 6 or 7 m in front of the aircraft, kinked at a height of about 40 cm, corresponding to the point where it is inserted into the ground to secure it. This is consistent with the rod being dragged and pulled out of the ground abruptly, causing it to bend and projecting it forcefully forward of the aircraft.

Given the marks and damage identified on the tail rotor blades and its drive and transmission system, it can be concluded that the tail rotor struck the aerial wire of the electrified fence, which then wrapped around the rotor, stretching the wire until it broke, leaving marks made by the steel braiding on the blade and causing the mechanical damage to the tail rotor yoke. This tension on the wire then moved three of the fence's supporting rods, bending the two at each end and dragging the central one until it was unearthed and projected vertically upwards, hitting and damaging the trailing edge of the horizontal tail stabiliser and then being propelled upwards again.

After that, the rod was thrown over the aircraft striking the main rotor as it passed, resulting in impacts and breakages to two of the three rotor blades. It hit the yellow blade on the underside of the tip, causing some material to break off, and then it hit the leading edge of the blue blade, damaging the main beam and propelling the rod to the ground. The shape and depth of the damage is consistent with being caused by an 8 mm diameter steel rod. Therefore, the marks and traces identified support this possible sequence of events.

Given that the rod was 1.5 m long, with about 40 cm buried in the ground and a cable tensioning insulator about 90 cm above the ground, and that the rotor blade operating area was about 1 m above the ground, despite the aircraft being aligned with the axis of the road and parallel to the electrified fence when the tail cone moved sideways during the climb, the tail rotor blades hit the wire.

The damage to both the tail and main rotors caused the intense vibrations that alerted the pilot, who, unable to control the manoeuvre, decided to land and, on exiting the aircraft, realised that there had been an impact with the aerial wire of the electrified fence.

2.3. Operational analysis

The pilot-in-command complied with the experience requirements established for firefighting operations. The operation was conducted respecting the established rest periods and the required flight and helicopter type limitations, following the operating procedures specified in the aircraft's flight manual.

In terms of the pilot's training specifically, the requirements of the organisation's OM had been met as he had received the required recurrent type training and proficiency checks for firefighting operations in recent months.

Firefighting operations often require flights to be made in uniquely complex conditions. In this case, the pilot was flying the second aircraft in the formation, and the designated landing area only had room for one helicopter at a time. As a result, he had to wait for the first aircraft in the formation to disembark its personnel before he could land. Given that several other aerial resources of different categories were operating in the area and in a reduced space, when he realised that, while waiting, he was in the path of the carousel of helicopters unloading water, he decided to move away and assess another landing site.

This decision was appropriate as he took into account the evolution of the firefighting activities and modified the flight to assess another landing site, despite the inherent challenges of choosing a secondary location that would most certainly be more challenging to land on due to the orography of the area. The pilot complied with the SOPs for operations in unprepared and/or mountainous areas.

The pilot took into consideration the location's proximity to the fire for disembarking the firefighting personnel. He reconnoitred the terrain, identifying a forest road in an unconfined area with a headwind that was large enough for the helicopter to land as the best possible option for disembarking the firefighters. In reality, the road was confined laterally to the right of the approach path, but its location provided adequate uphill access to the extinguishing scene and access to a possible downhill escape route in the event of any complications. According to his statement, the pilot identified the presence of an electrified fence before landing. It was an electrified line used to contain livestock, consisting of a metal wire attached to steel rods bordering both sides of the forest road, so he was fully aware of its existence.

The steel rods were rusty, which made them difficult to see as they blended in with the surrounding terrain, making them practically invisible to the human eye.

He made a controlled approach and cleared the thick layer of dust obscuring his view from a high hover, then landed safely in the available space in the middle of the road, following standard operating procedures.

After disembarking the firefighters and preparing the helibucket, he took off again to continue with the mission. According to the aircraft's records, it was in the area of the downhill slope in a low-altitude hover with the influence of ground effect when the pilot made minor pedal corrections and immediately noticed a significant vibration in the flight controls that made it difficult to control the manoeuvre, so he decided to perform an autorotation manoeuvre from the hover and land back on the road. In fact, according to the records, the aircraft did not autorotate, and the engine functioned normally.

This phase lasted 2' 33" according to the records, which also confirm that the tail cone made several clockwise and counter-clockwise yaws, with slight ascents and descents, which could be due to the minor pedal corrections reported by the pilot and the subsequent

uncontrolled movements. In one of the yaws, the tail rotor reached the aerial wire of the electrified fence, which was approximately 1 m above the ground, resulting in the succession of events described in the previous section.

The orography of the terrain promoted the appearance of turbulence in normal conditions due to the irregularities, the differences in height between the different points, the natural barriers, the vegetation in the area and the different slopes.

The effect of the fire also produced a rise in temperatures in the area, facilitating the appearance of additional turbulence on the slope.

The turbulence caused by the terrain and the fire, even if only minor, could have contributed to the need to make the pedal corrections which brought the aircraft into contact with the conducting wire. The space was limited, hindering an already complex operation with special operating conditions, and although the pilot was aware of the electrified fence, a possible error in judging its height and its distance from the aircraft may have led to the impact with the tail rotor that caused the accident. The fact that the wire was thin and the rods supporting it were rusty and blended in with the ground, making them very hard to see, may have contributed to the error of judgement.

When the pilot realised he could not control the flight controls, he decided to perform a manoeuvre that he defined as autorotation to position the helicopter safely on the road as soon as possible. To do this, he lowered the collective pitch and cut the throttle. This operation was safe and controlled, but damage had already been caused to both rotors by dragging one of the electrified fence rods, which was then propelled in front of the helicopter.

3. CONCLUSION

3.1. Findings

- The landing site selected to disembark the firefighting brigade was a forest road in a mountainous area, laterally confined by an uphill slope and an electrified cattle retaining fence on both sides of the road.
- The damage to the aircraft was consistent with the tail rotor impacting the aerial wire of the electrified fence and subsequently dragging one of its support rods, which then struck the fuselage and main rotor.
- Based on the analysis of the marks on the ground and the damage to the aircraft, we have concluded that the emergency landing was executed in a controlled manner with the aircraft stabilised.

3.2. Causes / Contributing factors

The investigation has revealed the probable cause of the accident to be a manoeuvre that did not comply with the limits of the area chosen for the operation, which caused the tail rotor to hit the aerial wire of an electrified fence and pull out its ground support rod, which in turn impacted the fuselage and the main rotor.

As a result of the damage to the helicopter, the pilot had to make an emergency landing on the road from which he had taken off.

4. RECOMMENDATIONS

No operational safety recommendations are proposed.