CIAIAC

COMISIÓN DE INVESTIGACIÓN DE ACCIDENTES E INCIDENTES DE AVIACIÓN CIVIL

Report A-045/2020

Accident involving an Airbus Helicopters MBB BK117 D-2/H145 aircraft operated by Eliance Helicopter Global Services, registration EC-MJK, on 16 November 2020 in the municipality of Piera (Barcelona, Spain)

GOBIERNO DE ESPAÑA

MINISTERIO DE TRANSPORTES, MOVILIDAD Y AGENDA URBANA

Edita: Centro de Publicaciones
Secretaría General Técnica
Ministerio de Transportes, Movilidad y Agenda Urbana ©

NIPO: 796-22-013-6

Diseño, maquetación e impresión: Centro de Publicaciones

COMISIÓN DE INVESTIGACIÓN DE ACCIDENTES E INCIDENTES DE AVIACIÓN CIVIL

Tel.: +34 91 597 89 63
Fax: +34 91 463 55 35
E-mail: ciaiac@mitma.es
http://www.ciaiac.es
C/ Fruela, 6
28011 Madrid (España)

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 and its 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 5.6 of Regulation (UE) nº 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 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.

Contents

Abbreviations

° ′ ″	Sexagesimal degrees, minutes and seconds
ºC	Degrees Celsius
%	Per cent
AEMET	Spain’s State Meteorological Agency
AESA	Spain’s National Aviation Safety Agency
AGL	Above ground level
AOC	Air operator certificate
ATPL	Airline Transport Pilot License
CCAA	Autonomous Community
CPL(H)	Commercial Helicopter Pilot License
D	The largest dimension of the helicopter with the rotors turning
EHEST	European Helicopter Safety Team
FDR	Flight data recorder
FFS	Full flight simulator
FOD	Foreign object damage
FSTD	Flight simulation training device
ft	Feet
ft/min	Feet/minute
h	Hours
HEMS	Helicopter emergency medical service
IR	Instrument rating
KIAS	Knots-indicated airspeed
km	Kilometres
km/h	Kilometres/hour
kt	Knots
LDP	Landing decision point
LERC	ICAO code for the Parc Tauli heliport
m	Metres
METAR	Aviation routine weather report (in aeronautical meteorological code)
MMI	Mast moment indicator
MP	Multi-pilot
MPL	Multi-crew Pilot License
MTLA	Minimum take-off and landing area
MTLS	Minimum take-off and landing surface
MVH	Helicopter flight manual
ICAO	International Civil Aviation Organisation
PF	Pilot flying
PICUS	Pilot-in-command under supervision
SP	Single pilot
SPA	Special purpose aircraft

TAF	Terminal aerodrome forecast
UTC	Universal Time Coordinated
VFR	Visual flight rules
VTOL	Vertical take-off and landing
V_{TOSS}	Take-off safety speed
V_y	Best rate of climb

Synopsis

Owner:	Waypoint Asset Euro 1f Limited
Operator:	Eliance Helicopter Global Services
Aircraft:	Airbus Helicopters MBB BK117 D-2/H145,registration EC-MJK (Spain)
Date and time of accident:	16 November 2020, 10:39 h[1]
Site of accident:	Municipality of Piera (Barcelona)
Persons on board:	2 (1 pilot, 1 HEMS crew-member) and 2 (passengers[2])
Type of flight:	Commercial Air Transport - Emergency medical service
Phase of flight:	Landing
Type of operation:	VFR
Date of approval:	28 April 2021

Summary

On Monday, 16 November 2020, the aircraft departed from Taulí hospital in Sabadell to provide emergency medical assistance to a resident of Piera, in Barcelona. A HEMS (helicopter emergency medical service) technical crew member and a medical team comprising a doctor and a nurse were on board the aircraft with the pilot.

The helicopter pilot selected a landing site close to the home of the patient they were to assist. The slope in the chosen area exceeded the established limits[3], causing one of the main rotor blades to hit the upper cable cutter when the pilot lowered the collective to settle the aircraft after touch down.

The people on board the helicopter were unharmed.

The helicopter sustained significant damage.

The investigation has determined the accident occurred as a result of landing, contrary to the procedures, in a confined area[4] with a slope that exceeded the established limits.

No safety recommendations are proposed.

[1] All times used in this report are local time. The UTC is 1 hour less.
[2] The passengers were the emergency medical team (one doctor and one nurse).
[3] The landing surface slope limits are shown in Annexe II of this report
[4] The helicopter landed on a slope in a "confined area" with both power and telephone lines, as well as vehicles and wheeled rubbish containers whose lids blew open as the helicopter approached.
A "confined area" is defined as one with obstacles that requires a steeper than normal approach, where the manoeuvring space in the ground cushion is limited, or whenever obstructions force a steeper than normal climb-out angle. (Definition taken from EHEST's "Helicopter Flight Instructor" manual)

1. THE FACTS OF THE ACCIDENT

1.1. Overview of the accident

On Monday, 16 November 2020, the aircraft departed from Taulí hospital in Sabadell to provide emergency medical assistance to a resident of Piera, in Barcelona. A HEMS (helicopter emergency medical service) technical crew member and a medical team comprising a doctor and a nurse were on board the aircraft with the pilot.

The helicopter pilot selected a landing site close to the home of the patient they were to assist. The slope in the chosen area exceeded the established limits, causing one of the main rotor blades to hit the upper cable cutter when the pilot lowered the collective to settle the aircraft after touch down.

The people on board the helicopter were unharmed.

The helicopter sustained significant damage.

1.2. Injuries to persons

Injuries	Crew	Passengers	Total in the aircraft	Others
Fatal				
Serious				
Minor				
None	2	2	4	
TOTAL	2[5]	2[6]	4	

1.3. Damage to the aircraft

The accident damaged the following components of the helicopter: the cable cutter system, a main rotor blade, the front copilot window and one of the skid struts.

1.4. Other damage

There was no additional damage.

1.5. Personnel information

1.5.1. Information on the pilot

The 47-year-old pilot had a commercial pilot license for helicopters, (CPL(H)), first issued on 02 April 2012, with the following ratings: EC135/635/IR/SP/MP, valid until 28 February 2021, and EC145 (BK117)/SP, valid until 30 September 2021.

[5] The crew consisted of the pilot and the HEMS technical crew member
[6] The passengers were the emergency medical team (one doctor and one nurse)

He had a Class 1 medical certificate (single-pilot commercial operations transporting passengers) valid until 14 March 2021.

His experience was 2190 total flight hours, thirty of which were during the three months prior to the accident and all in HEMS operations. For his previous employer, he flew EC135 helicopters, and at Eliance, for whom he had been working for approximately two years, he flies EC145 helicopters. He estimated that he would have flown roughly 1300 to 1400 hours in EC135 helicopters and about seventy to eighty hours in EC145 helicopters.

He has been a HEMS commander for two years. Before that, he was a pilot-in-command under supervision (PICUS) for approximately six years. He had also served as a HEMS technical crew member.

During the investigation he explained that, as part of his recurrent training, training for slope landings only using the flight simulator was received. However, given that the landings made during the daily provision of the HEMS service often involve landing on sloping terrain, he believes pilots acquire sufficient training during everyday operations, making additional training unnecessary.

1.5.2. Information about the HEMS technical crew member

The 30-year-old HEMS technical crew member held a commercial helicopter pilot license (CPL(H)), first issued on 28 March 2017, with a Bell212/412/SP rating valid until 31 March 2021.

He had a Class 1 medical certificate (single-pilot commercial operations transporting passengers) valid until 31 May 2021.

He had around 900 h of experience as a HEMS technical crew member in EC135 and EC145 helicopters.

1.6. Aircraft information[7]

- Make: Airbus Helicopters
- Model: MBB BK117 D-2/EC145
- Year of manufacture: 2015
- Serial number: 20055
- Registration: EC-MJK
- Maximum take-off weight: 3650 kg[8]
- Number of engines: 2
- Type of engines: Turbomeca, model Arriel-2E

[7] Information extracted from the Type Certificate Data Sheet nº EASA.R.010 for MBB-BK117
[8] Information extracted from the Spanish Civil Aircraft Registry of AESA

- Information about the owner and operator: the aircraft was registered in the Spanish Aircraft Registry on 21 June 2016, with the sublessor being Eliance Helicopter Global Services.

The aircraft has an Airworthiness Certificate issued by AESA on 04 February 2016 and an Airworthiness Review Certificate valid until 13 March 2021.

The aircraft has a Certificate issued by AESA on 23 October 2020 to perform the next activities: customs, police, search and rescue, firefighting, coastguard or similar.

A photograph of the accident aircraft is attached:

Illustration 1: Photograph of the accident aircraft

The following photograph shows the aircraft's instrument panel:

Illustration 2: Instrument panel of the aircraft

1.6.1. The Mast Moment Indicator in rigid rotor helicopters

The accident aircraft has a mast moment indicator (MMI)[9] to avoid damaging the mast assembly during large cyclical displacements on the ground.

The indicator installed on the accident aircraft shows the total moment applied to the mast and a circle that makes it easy to determine the correct direction to move the cyclic control, as seen in the illustration to the right.

[9] In a rigid rotor helicopter, high bending forces can be transmitted to the main rotor shaft. In flight, when a pilot performs a cyclical movement, the main rotor disc tilts, the fuselage follows, and the mast bending moment is low. However, when the fuselage is in contact with the ground and cannot follow the main rotor disc, the bending moment can be very high.

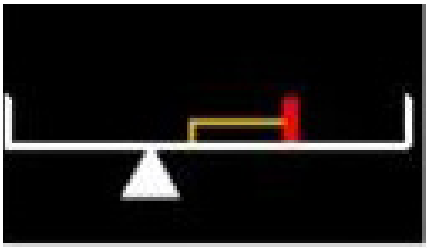
The mast moment indicator limits are as follows:

Orange circumference:	54% to 66%
Red circumference	> 66%
White circumference (end of the scale)	100%

The audio warning "MAST MOMENT" is emitted when the red circumference limit is exceeded.

The helicopter is also equipped with a one-dimensional indicator:

The pilot has to decide which direction to move the cyclic in order to reduce mast moment.



1.6.2. Performance and dimensions of the helicopter

The speeds relevant to the analysis of the accident are:

- V_{TOSS} (take-off safety speed) is 45 kt
- V_Y (best rate of climb speed) is relative to the altitude. It is automatically calculated and displayed on the IAS.

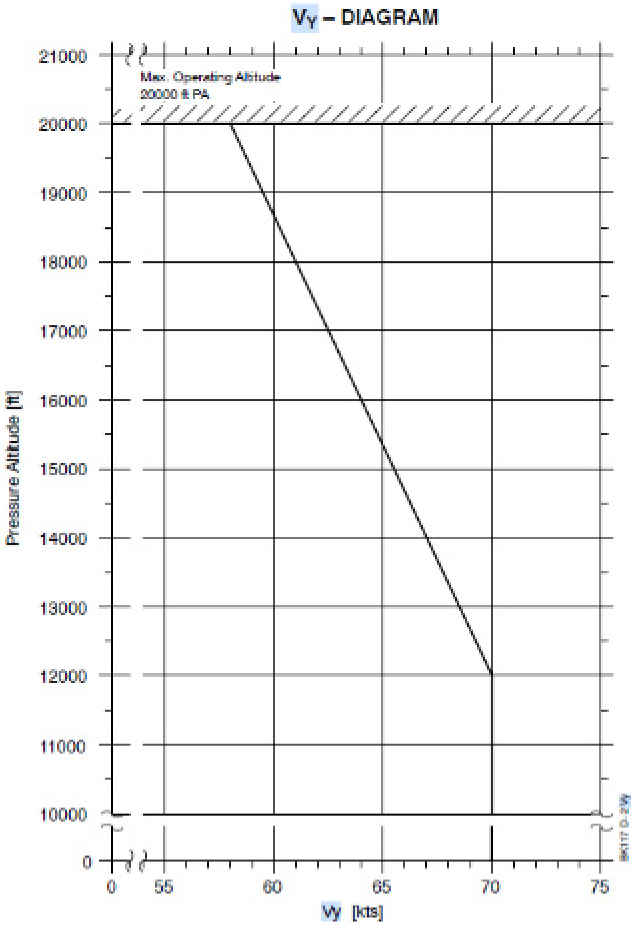


Illustration 3: Relation between VY and altitude

The following image shows the dimensions of the helicopter. Of particular interest is D, (the largest dimension of the helicopter with the rotors turning) which is 13.64 m.

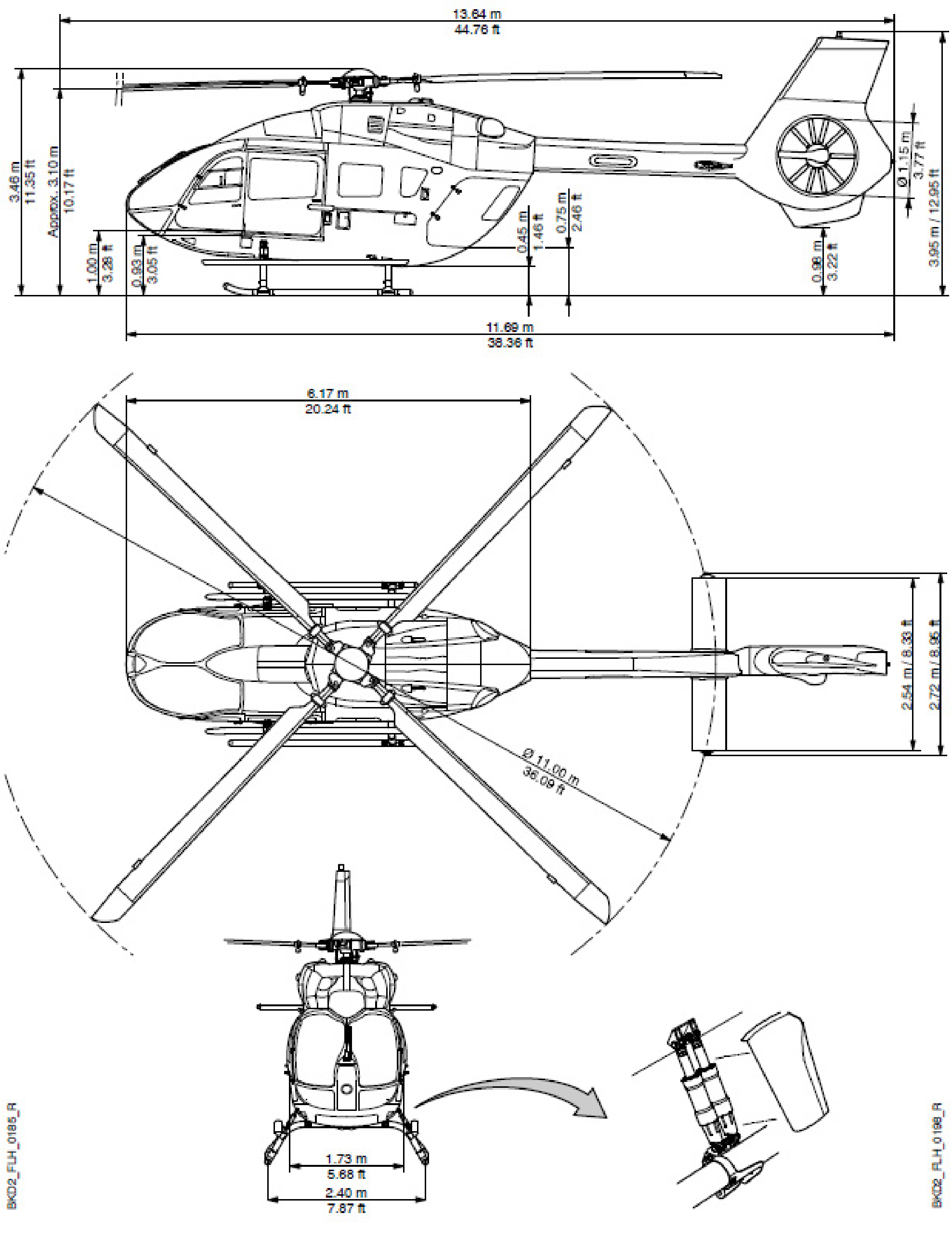


Fig. 7-1-1 Principal dimensions

Illustration 4: Dimensions of the accident helicopterv

1.7. Meteorological information

1.7.1. General meteorological conditions

An Atlantic ridge was forming at mid and upper levels, elongating and moving slowly eastward. Atmospheric subsidence over the Peninsula contributing to a general stabilisation. Deformation zone between the Peninsula and the Canary Islands, which were under a cyclonic circulation and west of a cold-core low of -15 ºC. At low levels, a cold front produced light rainfall in the north of the Peninsula and then moved away towards the east of the Balearic Islands. Stability prevailed with morning fog in many inland areas, lasting longer in the centre and dissipating before noon.

1.7.2. Meteorological conditions in the area of the accident according to AEMET

AEMET does not have a meteorological station in Piera; the nearest stations are at Montserrat (11 km to the northeast), Igualada (13 km to the northeast) and Villafranca del Penedés (20 km to the south). The closest airport is Sabadell (30 km to the east). The data recorded at these stations was as follows:

- Montserrat (temperature and rainfall): temperature around 13 ºC, relative humidity 88%.
- Igualada: temperature 16 °C, relative humidity 85%, average wind 2 km/h from the west and maximum wind speed 22 km/h from the west.
- Villafranca del Penedés: temperature 16 °C, relative humidity 91%, average wind 5 km/h from the southeast and maximum wind speed 23 km/h from the southeast.

The aerodrome report (METAR) from Sabadell was as follows:

METAR LELL 160930Z 22005KT 180V260 9999 FEW013 BKN020 16/13 Q1022=

And the forecast for the aerodrome at the time (TAF) was:

TAF LELL 160800Z 1609/1709 22008KT 9999 SCT025 TX19/1613Z TN09/1706Z PROB40 TEMPO 1615/1624 3000 RA BKN015 BECMG 1616/1618 VRB03KT

In short, the winds were light and visibility was good, although the humidity level was relatively high. The cloud ceiling was low, below 2000 ft.

According to AEMET, the available data shows no significant meteorological phenomena that could have contributed to the accident.

1.7.3. Meteorological conditions in the area of the accident, according to the pilot

Winds in the area were light, with speeds of between 5 and 8 knots from a 240º direction. Visibility was good.

1.8. Aids to navigation

N/A.

1.9. Communications

The following summary of the cockpit voice recording was used to analyse the accident:

The 112 emergency response call centre notified them that a person had fallen from about 3 m and lost feeling in the upper extremities. They were also informed that a football field in the residential area where the accident had occurred could provide a possible landing site. The helicopter took off at 10:27:14 h from Taulí hospital in Sabadell to provide medical assistance.

During the flight, the medical team requested the pilot to land as close as possible to the home of the person who needed medical assistance.

At 10:36:37 h, the HEMS technical crew member identified the house of the person to be assisted.

The pilot replied that, as the wind was 240º, he would have to go around to turn into the wind. He also mentioned that there were rubbish containers and a cable in the vicinity of the patient's home. Another option for the landing was a nearby field, but the pilot ruled it out as it was fenced off.

The pilot decided to land in the area close to the patient's home, just behind an ambulance. During the landing, the HEMS technical crew member, the doctor and the nurse helped the pilot to monitor the cables, poles and the position of the rubbish containers.

At 10:39:16 h, the HEMS technical crew member warned the pilot: *Watch out, Mast Moment!* and at the same time, the "MAST MOMENT" warning sounded. The HEMS technical crew member said to the pilot, *Pull up a moment, pull up a moment*.

At 10:39:18 h, the "MAST MOMENT" warning sounded again, and the pilot can be heard saying: *No, now*.

At 10:39:19 h, the sound of a rotor blade striking the aircraft cable cutter can be heard.

And at 10:39:20 h, the "MAST MOMENT" warning sounded for the third time.

At 10:39:57 h, once the helicopter was fully down and the occupants confirmed they were unharmed, they decided to disembark to assess what had happened.

1.10. Aerodrome information

The helicopter took off from the Taulí hospital in Sabadell (with ICAO code LERC) to provide emergency medical assistance to a patient who had suffered an accident in the municipality of Piera, in Barcelona.

The landing site has been marked in yellow in the image below. The GPS coordinates are: 41° 29′ 10.32″ N, 1° 46′ 3.00″ E. The street is about 17 m wide. In addition, a football field close to the home of the person requiring medical assistance has been marked in red. It was about 300 m away. The coordinating centre suggested this location as a potential landing site:

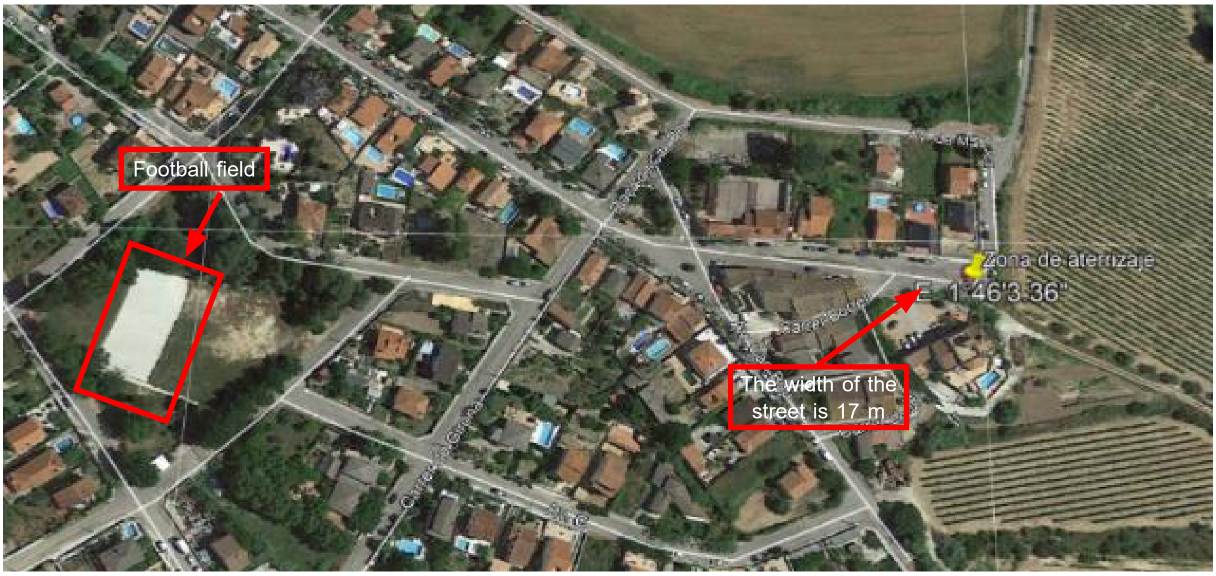


Illustration 5: Helicopter landing zone and location of football field

The following image illustrates the slope at the landing site, which has been calculated with the help of the parameters recorded by the data recorder, as explained in the following section:

Illustration 6: Slope at the helicopter landing site

1.11. Flight recorders

The aircraft was equipped with a flight data recorder and a voice recorder. Having consulted both we have deduced the following:

- The helicopter took off at 10:27:14 h (or 09:27:14 UTC) from Taulí hospital in Sabadell. It flew on a 248° heading for 7.5 minutes.
- At 10:36:37 h (or 09:36:37 UTC), they located the patient's home and made a 360° orbit to the right.
- At the point of landing, there were three pronounced longitudinal pitches (reflected in rapid variations of the PITCH ANGLE parameter, between -0.14° and + 13.48°).

  In the first one, the PITCH ANGLE rose sharply from -0.14° to + 10.31°; in other words, the helicopter tilted its nose upwards. The pilot had moved the cyclic control to an advanced-forward position (up to -20%). With the aircraft in contact with the ground, this cyclical position produced a MAST_MOMENT of 98%, activating the MAST_MOMENT_EXC alert one second later.

  The helicopter then pitched two more times. The pilot kept the cyclic control in an advanced-forward position. The MAST_MOMENT ranged from 70% to 98%. The aircraft slipped backwards. When the pilot lowered the collective to settle the aircraft, one of the main rotor blades struck the helicopter's upper cable cutter (coinciding with the extreme values of the longitudinal, lateral and vertical accelerations), and the noise of the impact can be clearly discerned in the recording from the cockpit voice recorder. The impact causes the aircraft to slip backwards again.

- They immediately stopped the engines and slowed the rotor when its revolutions were at 36%.

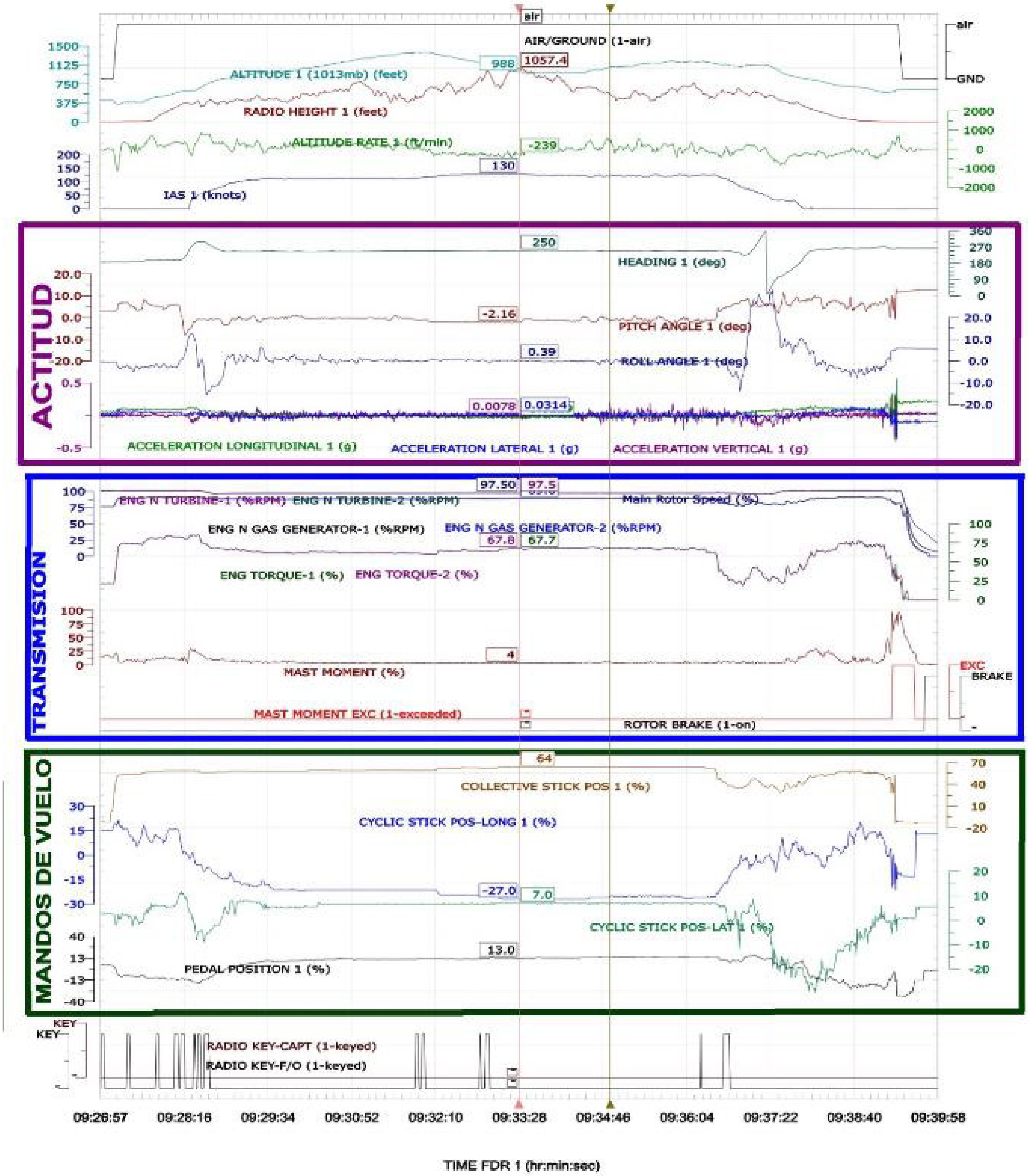


Illustration 7: Full flight parameters

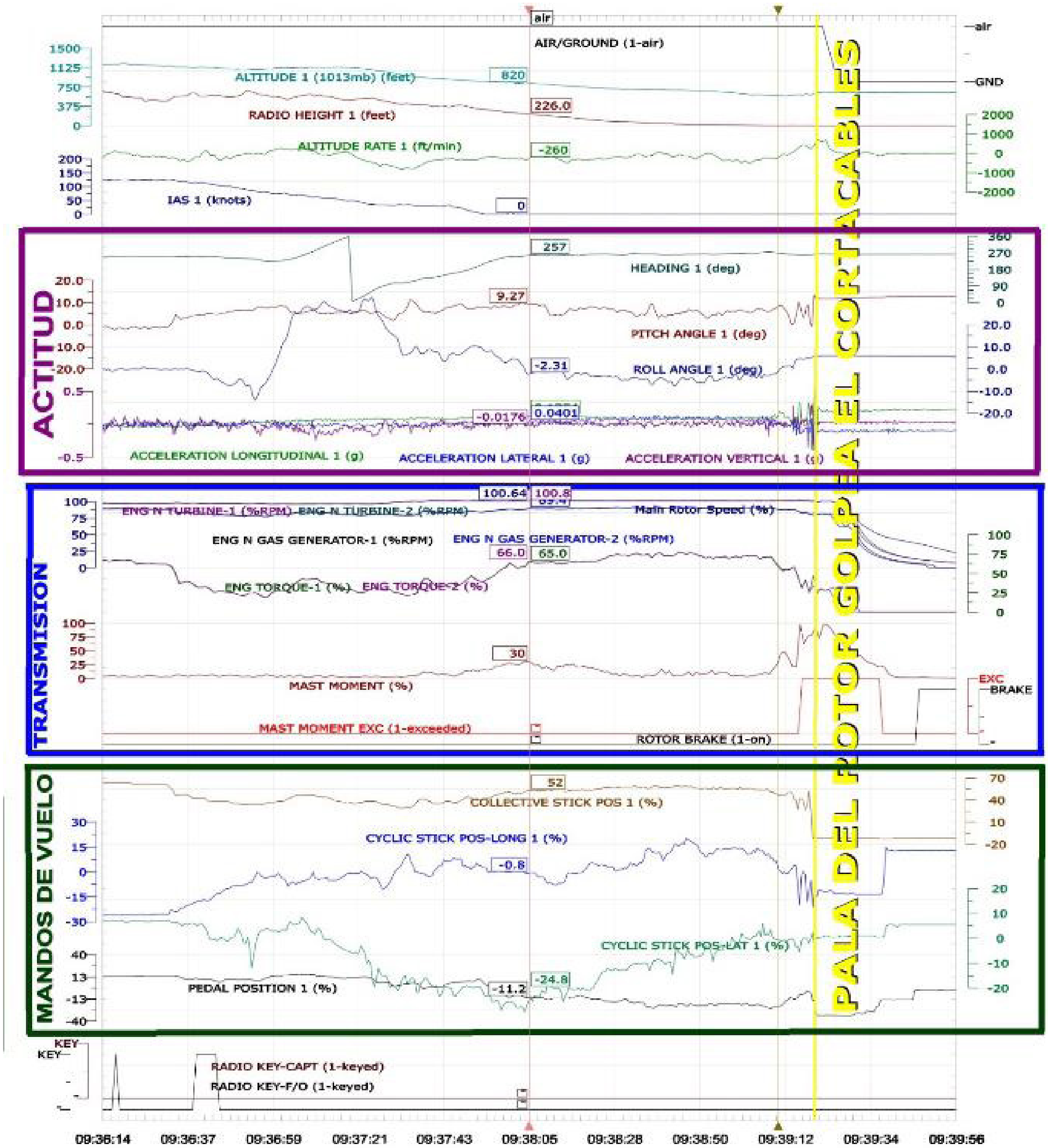


Illustration 8: Flight parameters in the moments leading up to the accident (I)

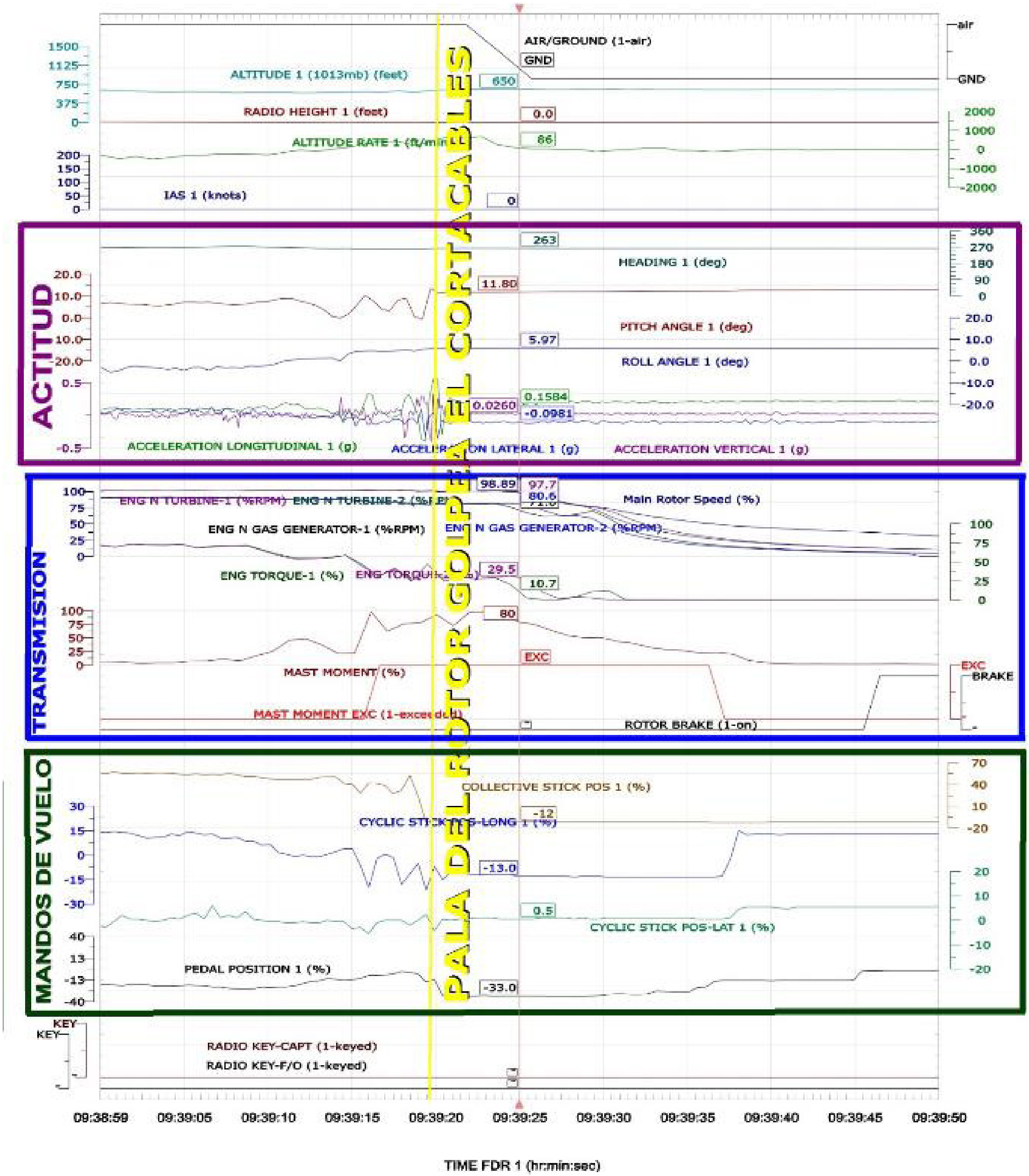


Illustration 9: Flight parameters in the moments leading up to the accident (II)

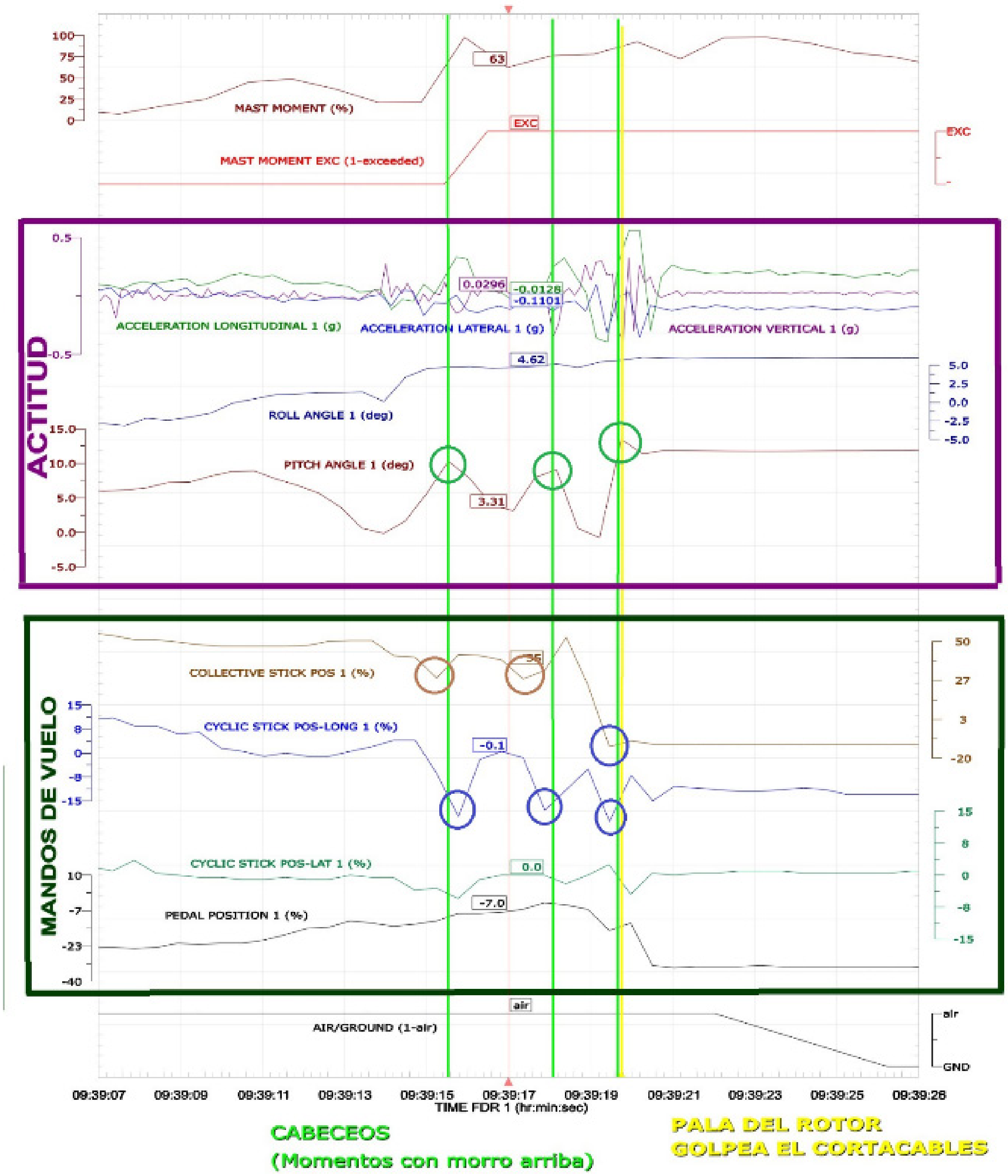


Illustration 10: Pitching movements during the accident

1.11.1. Calculation of the slope of the terrain at the landing site using the PITCH_ANGLE parameter

At the Taulí hospital heliport, the helicopter was stable with a PITCH_ANGLE of 3.10º. This represents a maximum 2% difference between the helicopter's position and horizontal[10], which is equivalent to ± 1.15º.

After landing at the accident site, the helicopter was stable at a PITCH_ANGLE position of 12.70º, a difference of 9.60º with respect to the value calculated at the starting heliport. This indicates that the slope of the terrain at the accident site is greater than 8º.

1.11.2. Aircraft's trajectory according to the tracking beacon data

The aircraft was equipped with a tracking beacon that recorded its trajectory. The following image shows the reconnaissance flight the pilot made to select an area for landing in the municipality of Piera:

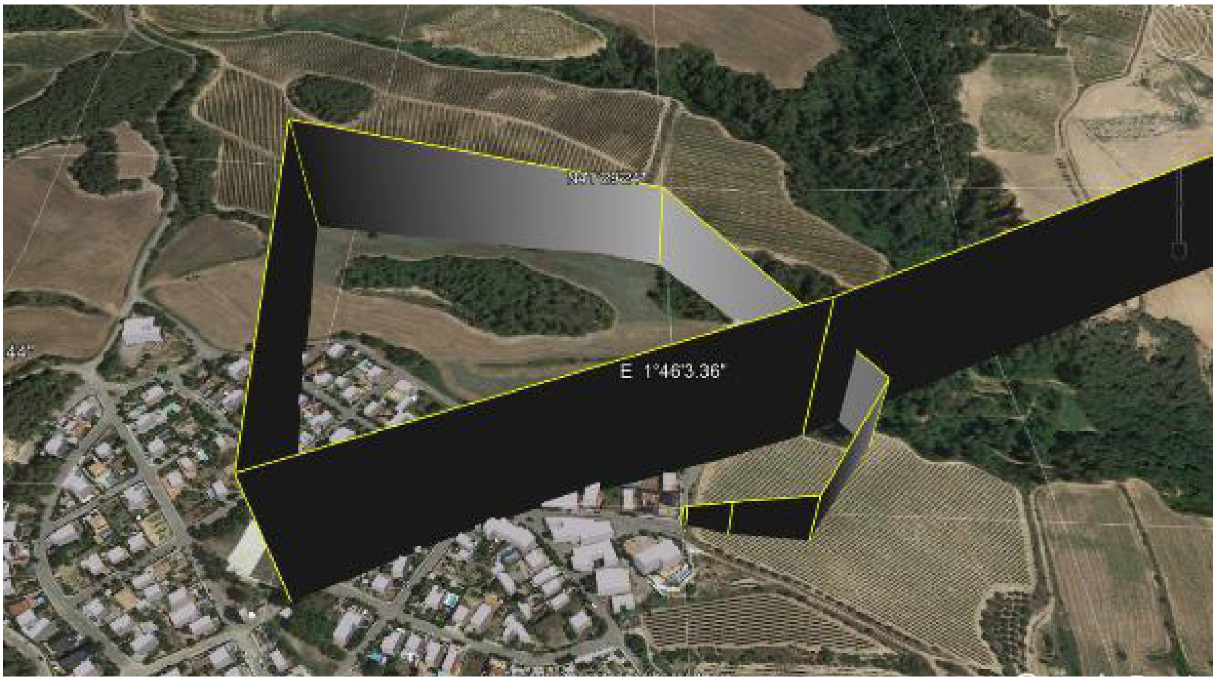


Illustration 11: Last moments of the flight before landing

[10] ICAO's Annexe 14 of Aerodromes Volume II Heliports recommends that when the final approach and take-off area (FATO) is solid, the slope should not exceed 2% in any directions, with the following exceptions:

b) when the FATO is elongated and intended to be used by helicopters operated in performance class 1, exceed 3% overall, or have a local slope exceeding 5%; and

c) when the FATO is elongated and intended to be used solely by helicopters operated in performance class 2 or 3, exceed 3% overall, or have a local slope exceeding 7%.

The Tauli hospital heliport is a certified heliport whose FATO has a minimum slope of 1% or 2% for rain drainage.

1.12. Aircraft wreckage and impact information

An individual recorded the helicopter landing with a video camera. The following images, taken from the video, show the rotor blade striking the upper cable cutter. The cable cutter was ejected by the rotor after turning approximately 270° with the blade that struck it. The red circle indicates the position of the cable cutter at different moments.

As can be seen in the recording, the pilot was unable to set the helicopter skid down correctly on the ground due to the sloping terrain during his first attempt.

On the next attempt, the helicopter pitches, and the pilot overrides the movement by lowering the collective. The rotor disc lowers, and the fuselage rises, causing one of the main rotor blades to impact the upper cable cutter. The following images show the magnitude of the damage:

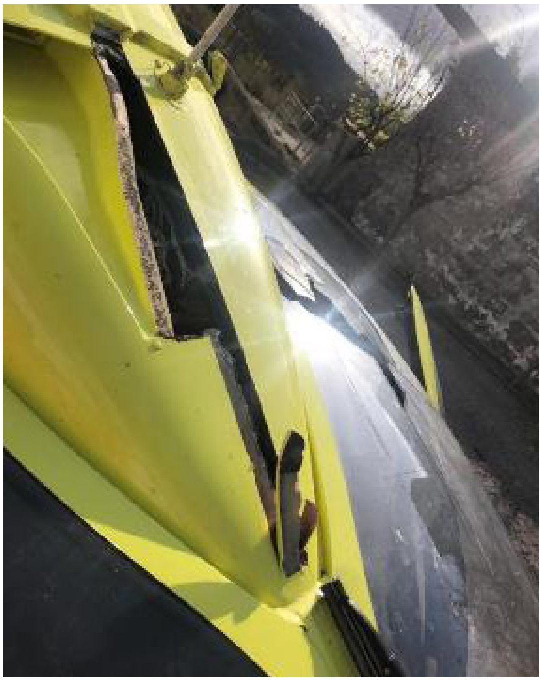


Illustration 13: Detail of the damage to the front window and cable cutter

Illustration 14: Detail of the damage to one of the main rotor blades

1.13. Medical and pathological information

We have found no evidence to suggest the flight crew were affected by any physiological or disabling factors.

1.14. Fire

There were no signs of fire during the flight or after the impact.

1.15. Survival aspects

The harnesses and restraint systems worked adequately and the cabin interior maintained its structural integrity.

1.16. Tests and research

N/A.

1.17. Organisational and management information

Eliance Helicopter has an Air Operator Certificate (AOC) for SPA HEMS IR-MP operations with EC135T3 and BK117 D-2 helicopter fleets.

Eliance Helicopter carries out HEMS operations in several Autonomous Communities. It has accumulated more than 250000 flight hours. It flies approximately 12000 hours annually, of which more than 6000 are accounted for by HEMS operations.

1.17.1. Eliance helicopter's Operating Manual

Annexe I contains an extract from Eliance Helicopter's *Operating Manual* outlining the general criteria for selecting the location of HEMS operations.

Annexe III contains an extract from Eliance Helicopter's *Operating Manual* outlining the initial and recurring training for HEMS operations.

And, lastly, Annexe V contains an extract from Eliance Helicopter's *Operating Manual* outlining the functions of the HEMS technical crew member.

1.18. Additional information

1.18.1. Manufacturer's maintenance manual, Airbus Helicopters.

Annexe II contains information extracted from the Airbus Helicopters manual for the analysis of this accident, specifically, the slope limit for the landing surface, the dimensions of the take-off and landing area and the VTOL profile.

1.18.2. Internal report by Eliance Helicopter

In its internal report, the operator concluded that the accident occurred due to a loss of flight control during the landing manoeuvre, identifying two primary causes and one secondary cause to explain the accident:

Primary causes:

- *The crew did not execute the landing point inspection sequence from the air correctly and, for this reason, they neglected to identify the sloping terrain at the chosen landing site in sufficient time, focusing their attention on the obstacles in the area instead. The number of obstacles to be monitored generated a saturation of tasks for the crew, leading to a loss of situational awareness due to an excessive external focus.*
- *The crew did not manage the MM in accordance with the instructions issued by the company. During the landing manoeuvre, the pilot did not make the necessary cyclic corrections during the first full skid landing and induced a sequence of two oscillating movements that ended with a loss of control and the rotor impacting the upper cable cutter.*

The two primary causes are related to a failure to follow procedures.

Secondary cause:

Excessive focus on the environment outside the cabin. The crew did not complete the assessment of the landing site, beginning a direct approach to it without evaluating the slope of the terrain and the possible consequences from the air. This last cause is believed to be related to the pressure the medical team placed on the crew, given their concern for the patient's condition.

The operator has implemented the following measures to prevent a recurrence of similar accidents in the future:

- The flight operations department published an internal statement addressed to the flight and technical crews regarding the selection of landing sites and the performance of the helicopters.
- Having identified human error and a failure to correctly interpret the mast moment during the landing manoeuvre as the primary cause, the safety department recommends reinforced training for all the company's BK117 D-2 commanders, to include at least one flight instruction session on slope landings and mast moment management.

  In addition to the above, the safety department recommends reinforcing the mast moment interpretation and management sequence during FFS training using a scenario similar to that of this event.

- After identifying a malfunction in the DAU manufactured by Appareo, both the manufacturer and Airbus Helicopters have been informed.

1.18.3. Regulations applicable to the training of HEMS pilots.

1- Commission Regulation (EU) No 1178/2011 of 3 November 2011 laying down technical requirements and administrative procedures related to civil aviation aircrew. Appendix 9 of the Regulation governs the training, skill test and proficiency check for MPL, ATPL, type and class ratings, and proficiency check for IRs. According to Appendix 9, the training, skill test and proficiency check for helicopter type and class ratings will be carried out in:

a) an available and accessible FFS; or

b) a combination of FSTDs and the aircraft if a FFS is not available or accessible; or

c) the aircraft if no FSTD is available or accessible.

2- For its part, Commission Regulation (EU) No 965/2012 of 5 October 2012 laying down technical requirements and administrative procedures related to air operations. Also relevant is ORO.FC.230 Recurrent training and checking. The acceptable means of meeting this requirement indicates:

AMC1 ORO.FC.230 Recurrent training and checking

RECURRENT TRAINING SYLLABUS

a) Recurrent training …

Recurrent training should comprise the following:

.....

4) Aircraft/FSTD training

.....

(ii) Helicopters

(A) Where a suitable FSTD is available, it should be used for the aircraft/ FSTD training programme. If the operator is able to demonstrate, on the basis of a compliance and risk assessment, that using an aircraft for this training provides equivalent standards of training with safety levels similar to those achieved using an FSTD, the aircraft may be used for this training to the extent necessary.

(B) The recurrent training should include the following additional items, which should be completed in an FSTD:

— settling with power and vortex ring;

— loss of tail rotor effectiveness.

.....

e) Use of FSTD

1) Training and checking provide an opportunity to practice abnormal/emergency procedures that rarely arise in normal operations and should be part of a structured programme of recurrent training. This should be carried out in an FSTD whenever possible.

2) The line check should be performed in the aircraft. All other training and checking should be performed in an FSTD, or, if it is not reasonably practicable to gain access to such devices, in an aircraft of the same type or in the case of emergency and safety equipment training, in a representative training device. The type of equipment used for training and checking should be representative of the instrumentation, equipment and layout of the aircraft type operated by the flight crew member.

3) Because of the unacceptable risk when simulating emergencies such as engine failure, icing problems, certain types of engine(s) (e.g. during continued take-off or go-around, total hydraulic failure), or because of environmental considerations associated with some emergencies (e.g. fuel dumping) these emergencies should preferably be covered in an FSTD. If no FSTD is available, these emergencies may be covered in the aircraft using a safe airborne simulation, bearing in mind the effect of any subsequent failure, and the exercise must be preceded by a comprehensive briefing.

3.- In addition to the provisions of the aforementioned European Regulations, we also deemed it useful to analyse the content of section 4.1 on the *Differences between the helicopter and the FSTD* in the document "HE 10 Instruction and tests in Flight Simulation Training Devices (FSTD)" drafted by EHEST[11] and translated by AESA[12]:

The simulation must be appropriate to the task being trained. The need remains to include real aircraft hours in the training programme even when using high fidelity FSTD. If the performance of the simulator is inadequate, there is a risk that actions undertaken in training may be ineffective or inappropriate in the real environment and lead to negative training and safety issues.

The simulated environment provided by FSTDs is excellent for building confidence and competence, however, there is the potential that a false sense of security can be induced in the trainee, who may fail to appreciate the difference in consequences between the simulated environment and the real environment. This risk is more significant for a trainee with a low level of flying experience, particularly during ab-initio training.

[11] EHEST was one of the three pillars of the European Strategic Safety Initiative (ESSI), *a ten-year programme launched by EASA in 2006. The initiative's objective was to further enhance safety for citizens in Europe and worldwide through safety analysis, implementation of cost-effective action plans, and coordination with other safety initiatives worldwide. Specifically, EHEST brought together manufacturers, operators, research organisations, regulators, accident investigators and some military operators from all over Europe. It was co-chaired by EASA, Airbus Helicopters and the European Helicopter Association (EHA).*

[12] https://www.seguridadaerea.gob.es/es/prom-de-seguridad/promociones-de-seguridad

1.19. Special investigation techniques

N/A.

2. ANALYSIS

This section analyses various aspects such as: the selection of the landing area, the approach phase to the landing area, the training given to the pilots for slope landings, the landing carried out by the pilot in this accident and the functions and responsibilities of the HEMS technical crew member during the flight.

2.1. Analysis of the selection of an appropriate area for landing

Annexe III details the initial and recurrent training provided by the aircraft operator for HEMS operations. During the flight training course, the aircraft operator provides training on assessing suitable HEMS operating sites from the air. Training on this is also provided during the operator's proficiency check and line check.

Furthermore, Annexe I contains the general criteria established by the aircraft operator for the selection of the landing site. The procedure dictates that to determine the suitability of the landing site, a high and a low visual reconnaissance must be carried out to assess, among other aspects, any possible obstacles, the slope of the terrain and the dimensions of the landing surface.

Therefore, the aircraft operator had provided training and established procedures for the proper selection of a landing site.

According to the data recorded by the FDR, in this accident, the pilot performed a visual survey of the area chosen for the landing:

- At 10:37:06 h, he started a traffic circuit to reconnoitre the terrain. He had previously reduced speed so that when he began the reconnaissance, he was flying at 72 knots. During the circuit, he continued to slow down until completing it at 0 knots. During this period, he reduced the helicopter's height from 576 ft to 234 ft.
- At 10:38:05 h, he began a brief low reconnaissance. He reached the landing decision point at 10:38:20 h, with a descent rate of around 300 ft/min and zero speed.

Therefore, we have concluded that the pilot carried out adequate high reconnaissance but uncompleted low reconnaissance of the area as per the operator's procedures.

During the reconnaissances, the pilot assessed the terrain as having a slope of around 8º[13]. However, as evidenced by the subsequent events, this assessment was mistaken because the terrain's slope exceeded the established limit value.

Furthermore, the chosen landing site dimensions were less than 2xD (the largest dimension of the helicopter with the rotors turning); that is to say, 27.28 m, as seen in the video recording of the accident. Although the chosen area complied with the

[13] The limit values for the slope of the landing surface are shown in Annexe II

dimensions of the Minimum Take-off and Landing Surface[14] or MTLS, it did not comply with the Minimum Take-off and Landing Area[15] or MTLA dimensions. This appears to suggest the crew were used to landing in areas smaller than 2xD.

In addition, there were a series of obstructions such as electrical cables and containers in the chosen area, which had to be monitored by the helicopter's occupants during the approach manoeuvre. Again it appears the crew were accustomed to landing in areas with hazardous obstacles nearby.

Despite all this, the pilot decided to land in the area and ruled out other possible landing site options, such as:

- a fenced-off field, which he ruled out because it was fenced-off and they didn't have any shears to cut the fence.
- a football field, which was suggested by the SEM 112 coordinating centre but which the pilot had to rule out because it was about 300 m from the home of the person requiring medical assistance.

  It's estimated that landing on the football field would have delayed the medical team' actions by 15 or 20 minutes as the ambulance would have had to travel to the football field to collect them and take them to the patient, then, after stabilising the patient, board, transfer and disembark them all again in order to put the patient on the aircraft.

  If a patient with spinal cord damage does not receive anti-inflammatory drugs in the shortest possible time, inflammation can make the spinal cord injury worse. In addition, landing on football fields does not always guarantee that it will be easy to exit them and access them later with an ambulance.

When selecting the most suitable area for landing, the pilot prioritised it being as close as possible to the home of the person requiring medical assistance[16]. The pilot, in his desire to fulfil his mission and assist the patient as soon as possible, and despite the acoustic warnings from the helicopter, selected an unsuitable area for landing, as was later verified.

2.2. Analysis of the approach phase to the landing site

Just before landing, there were a considerable number of communications between the pilot and his companions. Both the HEMS technical crew member and the medical team notified the pilot of the situation of a number of obstacles (power lines, signs and rubbish bins) in the area selected for the landing.

[14] This surface is defined in Annexe II.
[15] This area is defined in Annexe II.
[16] During the assessment of the landing site, the medical team suggested it should be as close to the patient as possible.

2.3. Analysis of the pilot training for landing on slopes

Section 1.18 contains the regulations applicable to the training of HEMS pilots in Europe:

- Commission Regulation (EU) No 1178/2011 of 3 November 2011 lays down the technical requirements and administrative procedures related to civil aviation aircrew. Within that Regulation, Appendix 9 regulates the training that pilots carry out in a flight simulator whenever available and accessible.
- In addition, Commission Regulation (EU) No 965/2012 of 5 October 2012 lays down the technical requirements and administrative procedures applicable to air operations. The acceptable means of complying with *ORO.FC.230 Recurrent training and checking,* indicates that it should be carried out in an FSTD whenever available and appropriate.

Thus, both the European Regulations establish that the training should be carried out in a flight simulator. However, certain manoeuvres, such as landing on slopes, cannot be adequately trained in a flight simulator, as explained in the document "Teaching and Testing in Flight Simulation Training Devices (FSTD)" prepared by the EHEST group.

Furthermore, the aircraft operator has identified the exclusive use of simulator training for HEMS pilots as a contributing factor in this accident and has decided to reinforce the training of its BK117 D-2/EC145 pilots by including at least one flight instruction session on slope landings and mast moment management.

2.4. Analysis of the approach executed by the pilot

When landing, helicopter pilots must take great care not to exceed the mast moment limits. Generally, this is not difficult. However, when executing a roll-on landing or landing on a slope, it can be more critical. In these situations, the pilot needs to feel comfortable having the mast moment indicator near the limits while making tiny cyclic adjustments. The mast moment indicator installed on the accident aircraft displays a circle to help the pilot decide which direction to move the cyclic to reduce the mast moment. The video recording of the accident shows the aircraft landing at an angle to the longitudinal axis of the street (about 10° to the left of it). This complicated the manoeuvre even further, as the surface was sloping both longitudinally and laterally. In this case, the proximity of the main rotor to the side walls of the street could have produced an added destabilising effect.

According to the data recorded, at 10:39:16 h, the HEMS technical crew member warned the pilot: "Watch out, Mast Moment!" and at the same time, the "MAST MOMENT" warning sounded. At this exact moment, the mast moment had reached 98%. The HEMS technical crew member said to the pilot, *Pull up a moment, pull up a moment.*

At 10:39:18 h, the "Mast Moment" warning sounded again, and the pilot can be heard saying: *No, now*. After this second warning, the collective was lowered to settle the aircraft with the longitudinal cyclic in an extremely forward position, which caused a main rotor blade to impact the upper cable cutter a second later. As the slope of the landing surface exceeded the limit, the fuselage lifted, and the rotor disc lowered when the pilot actuated the cyclic to level the aircraft.

As the "Helicopter Flight Instructor Manual"[17] prepared by the EHEST group explains, the technique for landing on a slope says that if the limit of the cyclic control is reached once on the ground, the pilot must take off again. However, the pilot decided not to abort the landing and insisted on settling the helicopter several times, ignoring the repeated "Mast Moment" warning.

At 10:39:57 h, once the helicopter had landed and the occupants confirmed they were unharmed, they decided to disembark to assess the situation because the crew were unaware of what had happened. Before doing so, the two engines were brought to an emergency stop without following the stopping times indicated in the manual.

Given the possible structural damage, the pilot's decision to remain on the ground is deemed to have been correct.

2.5. Analysis of the functions and responsibilities of the HEMS technical crew member

We observed that the HEMS technical crew member performed the communications with Sabadell. This is not one of the functions and responsibilities of the HEMS technical crew member[18], although the HEMS technical crew member held a commercial helicopter pilot license and was, therefore, qualified to perform radiotelephone functions.

[17] See Annexe IV
[18] Annexe V details the functions and responsibilities of the HEMS technical crew member

3. CONCLUSIONS

3.1. Findings

- The chosen landing site was a confined, sloping area with power and telephone lines, as well as vehicles and wheeled rubbish containers whose lids blew open as the helicopter approached.
- The slope at the chosen landing site exceeded the limits established by the aircraft manufacturer.
- The dimensions of the chosen landing site were smaller than the limits established by the aircraft operator.
- The pilot ruled out a field near the home of the person requiring medical assistance as a landing site because it was enclosed by a fence.
- A football field about 300 m from the home of the person requiring medical assistance was also ruled out due to the patient's time-dependent pathology.
- During the approach to the landing area, there were a considerable number of communications between the pilot and his companions. Both the HEMS technical crew member and the medical team notified the pilot of the situation of a number of obstacles (power lines and rubbish bins) in the area selected for the landing.
- In accordance with the applicable European regulations, the aircraft operator trained its HEMS pilots exclusively in simulators.
- The pilot received three audible warnings to notify him that the mast moment had been exceeded.
- The pilot decided not to abort when he received the audible warnings that he had exceeded the mast moment.
- After the second audible warning that the mast moment had been exceeded, the pilot lowered the collective to settle the aircraft with the longitudinal cyclic in an advanced-forward position, which caused one of the main rotor blades to impact the upper cable cutter one second later.
- During the flight, the HEMS technical crew member took charge of communications despite this not being included in his duties and responsibilities.

3.2. Causes/contributing factors

The investigation has determined the accident occurred as a result of landing, contrary to the procedures, in a confined area with a slope that exceeded the established limits.

4. SAFETY RECOMMENDATIONS

No safety recommendations are proposed.

ANNEXE I GENERAL CRITERIA FOR SELECTING HEMS OPERATING SITES

In its manual, the aircraft operator establishes the criteria to be followed when selecting a HEMS operating site, which include, among others:

1.- For daytime VFR, the operator has determined that for non-pre-evaluated sites, the following reconnaissance procedure should be carried out:

- High reconnaissance: at V_{TOSS}, never less than 500 'AGL, free of obstacles, following the pattern of a traffic circuit, conditioning it to the place to be evaluated, descending in the tailwind section up to 200' AGL.
- Low reconnaissance: at V_Y, never less than 200 'AGL, free of obstacles. During this reconnaissance, the crew should evaluate any potential obstacles, terrain slope, dimensions, etc.

2.- The site's dimensions can be less than the minimums established in the HFM but not less than 2xD (the largest dimension of the helicopter with the rotors turning) in the case of daytime VFR.

3.- Location and elevation of relevant obstacles that may interfere with take-off, landing and manoeuvring profiles.

4.- Take-off and landing paths. Obstacles in the area of operation must meet the take-off and landing profiles defined in the HFM.

5.-Type and slope of the surface.

ANNEXE II: SLOPE LANDING LIMITATION, TAKE-OFF AND LANDING AREA DIMENSIONS AND VTOL PROFILE 1

The helicopter manufacturer's *Flight Manual (Flight Manual* BK 117 D-2) includes both the limitations for the slope landing and the minimum dimensions of the selected area for take-off and landing.

In particular, section 2.5.4 *Slope landing limitation* details the limitations of the slope landing:

Slope operations (take-off/landing) are limited by the maximum mast moment (normal range) and the slope of the terrain as follows:

- *Ground sloping nose down (if tail clearance allows)* *max 10°*
- *Ground sloping up to the right* *max 12°*
- *Ground sloping up to the left* *max 8°*
- *Ground sloping nose up* *max 8°*

The maximum achievable slope angle may be further limited by the character and friction of the landing surface

NOTE

- *When the attitude indicator is used to determine the slope, the normal attitude on ground of 3.5° nose up shall be considered. For example:*
  - *8° nose up slope = 11.5° nose up on attitude indicator*
  - *8° nose down slope = 4.5 nose down on attitude indicator*
- *During slope operations, it is recommended to switch the autopilot A. TRIM to OFF.*
- *Roll oscillations might occur during nose-up slope operations with high mast moment. When encountered, temporarily reducing the mast moment using aft cyclic will stop the oscillation immediately.*
- *In case of mast moment indication failure, maximum slope limit is 3°.*

In regard to the minimum required dimensions of the take-off and landing area, the aircraft manufacturer has established the following:

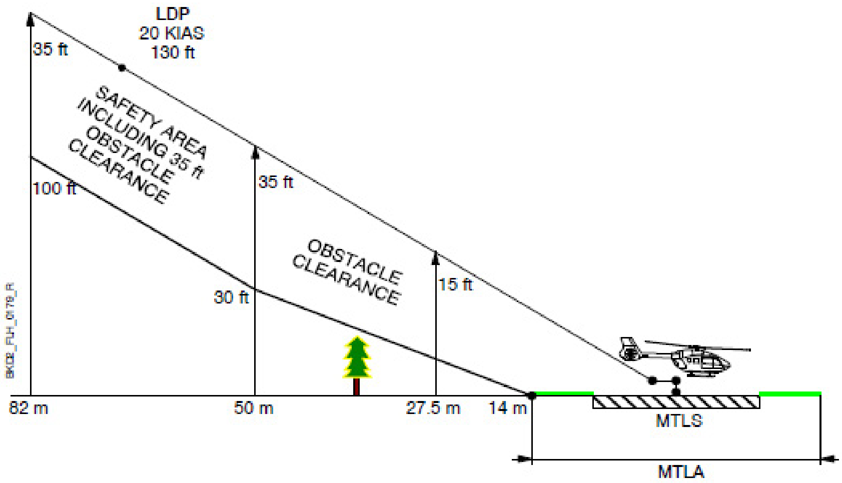


Fig. C2 Landing flight path obstacle clearance

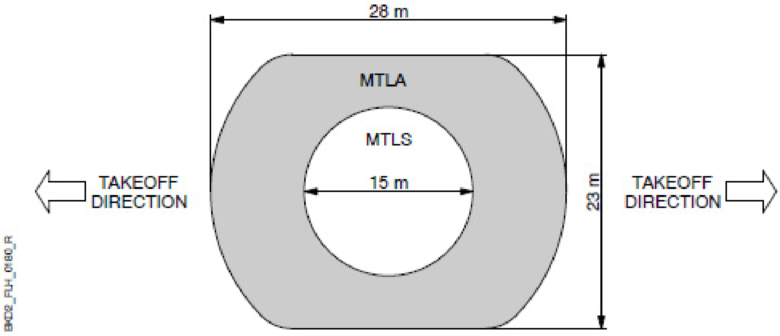


Fig. C3 Minimum Takeoff and Landing Area dimensions

We have also extracted the manufacturer's *Flight Manual* section that details how a landing should be performed following the VTOL profile.

- The diameter of the Minimum Take-off and Landing Surface[19] or MTLS shall be at least 15 m.
- The diameter of the Minimum Take-off and Landing Area[20] or MTLA shall be at least 28 m. The dimensions of the MTLA may be reduced to a width of 23 m in the direction of take-off/landing.
- The landing decision point (LDP) is at 130 ft, 20 KIAS and a descent rate of 300 ft/min.

[19] Minimum surface from and to which a safe take-off and landing (including rejected take-off and OEI landing) is conducted. It provides containment of the undercarriage including scatter encountered during normal or rejected landing. It must be load bearing and solid to provide a ground effect and shall be free of obstacles.

[20] The MTLA including the MTLS, which is free of significant obstacles and contains the entire helicopter (including tail boom and rotor). The area outside of the MTLS does not need to have a solid surface. It includes the normal scatter encountered during take-off and landing (including rejected take-off and OEI landing).

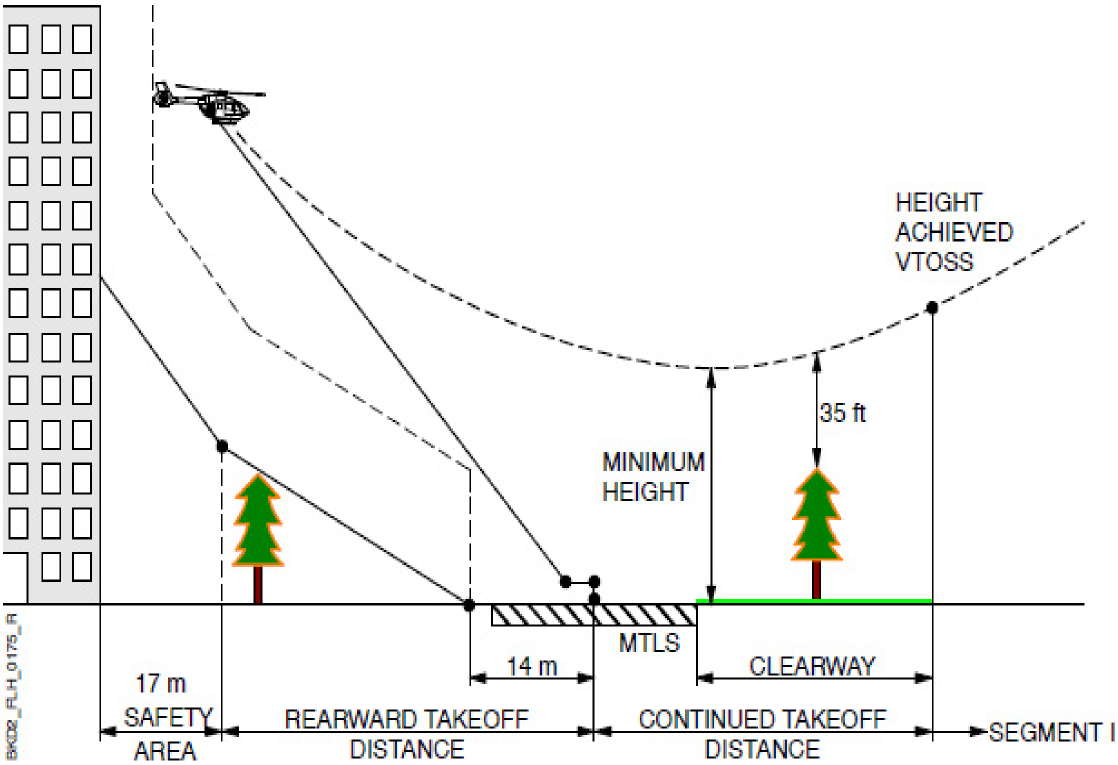


Fig. C1 Continued Takeoff Flight Path

ANNEXE III INITIAL AND RECURRENT TRAINING FOR HEMS OPERATIONS

The sections referring to initial and recurrent training have been extracted from the operator's *Operating Manual* for analysis of this accident:

1.- The operator may carry out flight training and skills verification in an aircraft or an FSTD. Line checks must be carried out in an aircraft.

2.- Content of the in-flight training:

- HEMS departure practices
- Assessing the suitability of HEMS operating sites from the air.

This content may be included within the recurrent training appropriate to the type of helicopter (section 2 of Part D of the *Operating Manual*).

- In-flight training to maintain IFR knowledge and experience
- Cross-checking instruments
- Interpreting the instruments
- Aircraft control
- Level flight by reference to instruments
- Ascent with constant speed and ratio

  Entry
  Levelling at the desired height
- Descent with constant speed and ratio

  Entry
  Levelling at the desired height
- Constant height turns:

  Turning to a specified heading
  Timed turns
  Changing speed during the turn
  Turning using a compass
- Ascending turns
- Descending turns
- Recovery from abnormal or unusual positions

3- Operator's Skills Verification

- Assessing the suitability of HEMS operating sites from the air
- Flight, take-off and landing profiles normally used at HEMS operating sites

4.- Line checks

- Knowledge of the HEMS work environment
- HEMS flight planning
- Local weather
- Crew coordination (including the HEMS crew members)
- Low altitude flight in adverse weather conditions
- Risk mitigation measures associated with low visibility conditions and risks in the HEMS environment
- Knowledge and preparation of the helicopter and specialised medical equipment for HEMS departures.
- Assessing the suitability of HEMS operating sites from the air
- Flight, take-off and landing profiles normally used at HEMS operating sites and familiarisation with those most used in the area of operation.

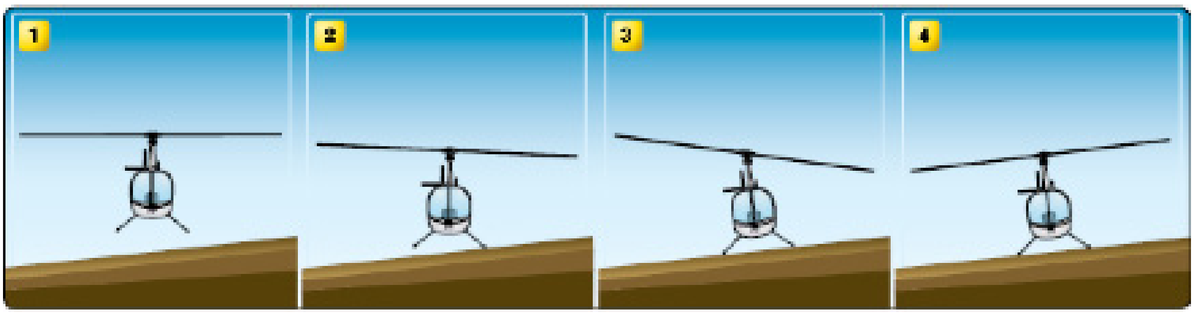
ANNEXE IV SLOPE LANDINGS

The EHEST "Helicopter Flight Instructor Manual"[21] explains the technique for operating from sloping ground:

1- The following steps should be followed when landing on a slope with left/right skid upslope:

- Establish a steady hover.
- Lower the collective gently until the upslope skid contacts the ground.
- Continue lowering the collective, at the same time moving the cyclic gently towards the slope keeping the disc horizontal to prevent lateral movement of the helicopter.
- When both skids are in full contact with the ground, smoothly lower the collective until it is fully down.
- Prevent yaw throughout.
- When certain the helicopter will not slide, centre the cyclic.
- It's important to maintain flying RPM until the collective is fully down.
- It's important to ensure smooth and accurate control movements without over-controlling. If only one side of the landing gear is in contact with the ground, it is possible to induce a rate of roll that is impossible to counteract with opposite cyclic.
- Cyclic control reaches its limit as the slope increases. If this occurs or the helicopter starts to slide, it should be brought smoothly back to the hover and landed elsewhere.

The following images, obtained from the FAA's "Helicopter Flying Handbook", illustrate the technique for landing across a slope with left/right skid upslope.



2.- To land with the aircraft nose up the slope, the technique is the same:

- The first contact is made with the front of the skids and then the cyclic is moved forward to keep the disc level as the collective is lowered.
- Caution should be exercised as both wheeled and skidded aircraft are prone to sliding down the slope.

[21] https://www.easa.europa.eu/document-library/general-publications/ehest-helicopter-flight-instructor-manual

EHEST developed the "Helicopter Flight Instructor" manual based on a manual produced by the Australian Civil Aviation Authority (CASA). EHEST incorporated European terminology, the *syllabus* and community experience in helicopter training

ANNEXE V: FUNCTIONS OF THE HEMS TECHNICAL CREW MEMBER

The functions and responsibilities of the HEMS technical crew member have been extracted from the operator's *Operating Manual*. They include, among other things:

a. Assist the commander to:

   1. collision avoidance;
   2. selection of the landing site; and
   3. detection of obstacles during approach and take-off phases.

b. If necessary, the commander may delegate other aviation tasks to the HEMS technical crew member, such as:

   1. assistance in navigation;
   2. assistance in radio communication/ radio navigation means selection;
   3. reading of checklists; and
   4. monitoring of parameters.

c. If necessary, the commander may also delegate to the HEMS technical crew member tasks on the ground, such as:

   1. assistance in preparing the helicopter and dedicated medical specialist equipment for subsequent HEMS departure; or
   2. assistance in the application of safety measures during ground operations with rotors turning (including: crowd control, embarking and disembarking of passengers, refuelling, etc.)

d. There may be exceptional circumstances when it is not possible for the HEMS technical crew member to carry out his/her primary task as defined under (a).

   a. This is to be regarded as exceptional and is only to be conducted at the discretion of the commander, taking into account the dimensions and environment of the HEMS operating site.)

This is in line with Commission Regulation (EU) No 965/2012 of 5 October 2012 laying down the technical requirements and administrative procedures applicable to air operations. Specifically, with the provisions of AMC1 SPA.HEMS.130(e) Crew requirements.

To fulfil these functions and responsibilities, the operator trains technical crew members in "helicopter radio and intercom operation" (if the technical crew member is not a helicopter pilot) in line with the provisions of AMC1 SPA.HEMS.130(f)(1) Crew requirements of the EU Regulation.