DATA SUMMARY

LOCATION

Date and time	**December 1, 2005; 12:17 local time**
Site	**Móstoles (Madrid)**

AIRCRAFT

Registration	**EC-HCT**
Type and model	**BELL 206 L4T**
Operator	**Helisureste, S. A.**

Engines

Type and model	**ALLISON 250-C20R**
Number	**2**

Crew

Pilot in command

Age	**29 years**
Licence	**Commercial pilot (helicopter)**
Total flight hours	**2,475 h**
Flight hours on the type	**1,507 h**

INJURIES

	Fatal	Serious	Minor/None
Crew			**2**
Passengers			**4**
Third persons			

DAMAGE

Aircraft	**Major**
Third parties	**Some damage to the vertical enclosure at Móstoles bullring**

FLIGHT DATA

Operation	**Aerial work – Commercial – Aerial observation and patrol**
Phase of flight	**Take-off**

REPORT

Date of approval	**30 May 2007**

1. FACTUAL INFORMATION

1.1. History of the flight

A Bell 206 L4T twin-engine helicopter, registration HC-HCT, operated by Helisureste, was being used in public service operations in a support role assisting municipal police units from different communities, in accordance with a contract agreement signed with the Autonomous Community of Madrid (CAM). On 1 December, 2005 the aircraft took off from the Cuatro Vientos airport at 10:23, en route to Móstoles. On board were the pilot and a police officer from the "Brigadas de Seguridad de la CAM" (Madrid Autonomous Community Security Brigades, BESCAM) who acted as an auxiliary crew member. The pilot had been informed that his activities for that day would consist of transporting public figures. The previous day, following the final flight, the fuel tanks had been fully replenished.

The aircraft headed for the bullring at the destination site, landing inside said facility ten minutes later. Plans called for the passengers to be transported later that morning to be embarked at this site.

Without shutting down the engines, and in order to practice the impending flight which would transport the public figures in question, the helicopter took off once again just minutes later, with a total of 5 persons on board.

The aircraft completed a route over the areas which it was scheduled to subsequently fly over, reaching La Eliana Park, also located within the Móstoles city limits. There the three persons who had previously boarded the aircraft were disembarked. The pilot decided that he had to burn more fuel given the weight conditions that he expected the aircraft to face later, and then completed another flight leg, accompanied by the auxiliary crew member. They returned to Móstoles and landed once again at the bullring, landing, on a westerly heading, at 11:30. The pilot shut down the engines and waited for the arrival of the public figures who were to be transported. From the initial flight at Cuatro Vientos airport until this point the aircraft had completed some 50 minutes of flight time.

At 12:15, with a total of 6 persons on board, 4 passengers plus the pilot and auxiliary crew member, the engines were started, and two and a half minutes later the takeoff was initiated.

From the moment in which the helicopter began to rise, in an essentially vertical manner, it initiated a rightward turn upon its vertical axis, progressively facing north and later Northeast, as it gained altitude. When the helicopter reached an altitude of 8 m and a heading of 150°, it ceased its ascent and turn, and began moving forward in order to leave the facility by passing over the area located between a light tower and a section of the building that serves as a stage for entertainment functions.

Initially maintaining its flight altitude, when it reached the area over the stands, the helicopter began to turn to the right on its vertical axis, while advancing to exit the ring. The speed at which the aircraft turned to the right began to increase, and once it crossed over the ring's stands, the helicopter began a rapid descent, impacting the exterior wall of the ring, and then the ground.

The aircraft came to rest turned over on the ground near the bullring's outside wall, resting on its left side. The pilot activated the switches in order to cut off fuel and electricity. There was no fire.

All the persons on board the helicopter had secured their safety belts, as had the crew members their safety harnesses. All those aboard remained conscious and, assisted by personnel in the area, individuals that formed part of the retinue which had accompanied the public figures travelling aboard, evacuated the helicopter, which had been destroyed. There were no serious injuries. Two passengers suffered slight injuries from the impact, with some cuts and bruises.

1.2. Injuries to persons

Injuries	Crew	Passengers	Total on the aircraft	Others
Fatal				
Serious				
Minor		2	2	Not applicable
None	2	2	4	Not applicable
TOTAL	**2**	**4**	**6**	

1.3. Damage to the aircraft

The landing skids, tail cone and rotor, and the blades and head of the main rotor head were detached. The main fuselage and the passenger and crew compartment were almost fully intact, except for minor breakage and deformation on its exterior.

It is considered that the aircraft was destroyed.

1.4. Other damage

Slight damage was noted on the outside wall of the ring, and to one of the doors, due to the impact with the landing skids and the main rotor blades.

1.5. Personnel information

1.5.1. *Pilot*

Age:	39 years
Nationality:	Spanish
Certificate and licence	Commercial helicopter pilot
Licence valid until	01-12-2005 (1 December 2005)
Valid type ratings:	Bell 206[1], Bell 407
Transition Course for Bell 206 4LT:	13-02-2004
Total flight hours	2,475:00 h
Total flight hours on Bell 206:	1,507:00 h
Total flight hours on Bell 206 L4T:	96:35 h
Flight hours in last 24 hours:	01:30 h
Flight hours in last 7 days:	05:45 h
Flight hours in last 30 days:	13:15 h
Flight hours in last 90 days:	79:50 h

The pilot initiated his activity at 09:30, and had previously rested more than 12 hours.

The pilot completed the transition program for the Bell 206 to Bell 206 L4 on 13 February, 2004, and over the last year had accumulated a total of 34:05 h on this type of helicopter, distributed according to the following diagram:

The pilot had 2 days of experience in the service of the BESCAM. He had been sent there on a temporary basis as a substitute pilot, at the same time logging the hours necessary for the renewal of his licence rating on the model in question. The pilot had completed the proficiency flight and competency check for his rating renewal on the Bell 206L4T on 29 November 2005, during this substitution period.

Upon relieving the outgoing pilot, the incoming pilot, who would later pilot the accident flight, was informed by the outgoing pilot regarding the types of flights regularly carried out as part of this service: flights with police on board, and possibly one more support

[1] The type rating for the Bell 2064LT was implicitly covered by that held for the Bell 206, in accordance with the reprieve permitted under the second «Disposición Transitoria» (Transitional Ordinance), Point 2 of the Ministerio de Fomento´s Regulation (OM) 3811/2004 (*BOE* Num. 281). Following the entrance into effect of the OM on 23 November, 2004, a different rating is required for each model.

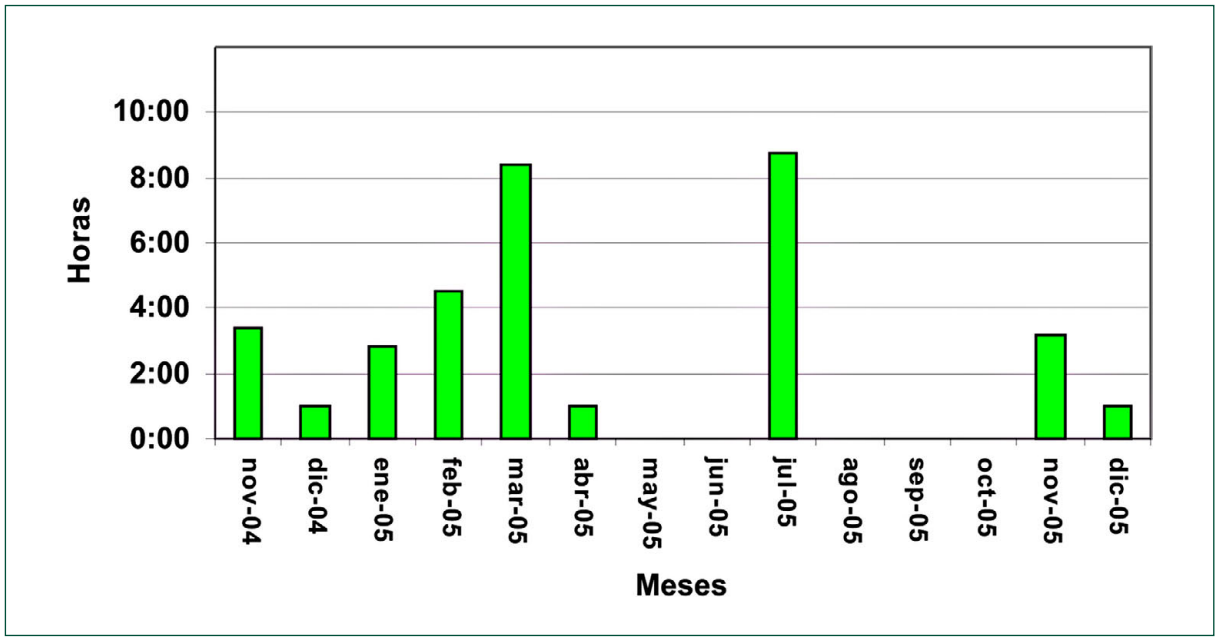


Figure 1. Flight hours over the last year on the Bell 206 L4T model

flight of variable duration, for which it was advisable to ensure maximum range, and local flights, principally over the locality of Móstoles, with take-off and landing generally carried out at the Cuatro Vientos Airport, the helicopter's base of operations.

1.5.2. *Auxiliary crew member*

A Móstoles municipal police officer, attached to BESCAM, was seated as an auxiliary crew member in the left seat, the spot normally occupied by the copilot, and was carrying out surveillance and observation tasks.

He had some 40 flight hours aboard the helicopter and had known the pilot for 2 days.

1.6. Aircraft information

1.6.1. *General*

The aircraft held a valid airworthiness certificate, and its registration information was the following:

Type:	BELL
Model:	B 206 L4T
Construction number:	52062

Year of construction:	1994
Registration	EC-HCT
Engines:	2 Allison 250-C20R
MTOW:	2,063.5 kg
Minimum crew:	One pilot
Owner:	Helicópteros del Sureste, S.A. (Helisureste)
Operator:	Helicópteros del Sureste, S.A. (Helisureste)
Airworthiness Certificate:	n° 4445. Issued on 30 November 2006

The modification of the B 206 L4 model to the twin-engine L4T was carried out in accordance with the supplemental type certificate (STC) SR0036SE (with the installation of 2 Allison 250-C20R engines and associated systems) approved by the U.S. Federal Aviation Administration (FAA). As of the date of the accident, a total of thirteen helicopters had been converted to B 206 L4T models.

The spin direction of the main rotor as seen from above is counter-clockwise.

1.6.2. *Helicopter maintenance*

The helicopter's maintenance logs were in compliance with the established maintenance program.

1.6.3. *Fuel*

The previous afternoon the helicopter had fully refueled its tanks. This was a common practice after completing the day's activity, as it left the helicopter ready and with the greatest possible flight range.

During the inspection of the helicopter after the accident, the fuel gauge located on the instrument panel was found to read 505 lb.

1.6.4. *Estimate of the helicopter's weight*

The helicopter completed two flights from the bullring, the first with five persons on board, and the second with six persons on board, during which the accident occurred. The estimated takeoff weights were the following:

	Flight no. 1	Flight no. 2
Basic Weight[2]	1,449 kg	1,449 kg
Luggage Compartment	24 kg	24 kg
Crew	180 kg	180 kg
Passengers	243 kg	335 kg
Film Equipment		5 kg
Fuel	280 kg	229 kg[3]
Totals	**2,178 kg (4,802 lb)**	**2,222 kg (4,899 lb)**

1.7. Meteorological information

The event in question took place southwest of the Cuatro Vientos aerodrome (LEVS), 8 km from the head of its Runway 28, and Northwest of the Getafe Military Aerodrome (LEGT), 13 km from the runway centerline. The area does not include any important geographical features which could result in significant variations in wind direction or intensity.

The relevant METAR information in both aerodromes is the following:

	12:00 LEGT	13:00 LEGT
Wind (direction)	230°	260°
Variable Winds		220° a 300°
Winds (intensity)	7 kt	12 kt
Gusts		22 kt
Visibility	8,000 m	9,000 m
Temperature	2 °C	2 °C
QNH (mb)	1,013	1,013

	12:30 LEVS
Winds (direction)	250°
Variable Winds	220° a 280°
Winds (intensity)	11 kt
Gusts	
Visibility	CAVOK
Temperature	2 °C
QNH (mb)	1,013

The diagram reflecting the history of the wind's average direction and minimum and maximum speeds at the head of the LEVS runway 28 showed a shift in these readings beginning at 11:40 local time. The average direction stabilized at a reading of

[2] The basic weight refers to the weight of aircraft when empty, plus the engine oil, plus the added elements forming part of the helicopter's configuration at the time.

[3] The fuel was extracted and measured in order to calculate its weight. The weight of the passengers was estimated based on their own statements in the cases in which they were provided for the investigation or, in those cases in which they were not, according to the standard weights as established in the company's operations manual.

approximately 240°, while the maximum wind speed stabilized at approximately 17 kt. The average speed continued to increase until 12:10, at which time it began to drop.

Press photos and video footage included images of a flag raised outside the ring in which a southwesterly wind of some intensity was in evidence, and which could be estimated to be similar to the METAR readings at LEVS and LEGT.

The wind inside the ring at ground level was of less intensity than that outside the bullring facility, but it was sufficient to slightly move the blades on the tail rotor, as could be observed in footage taken.

1.8. Aids to navigation

Not applicable.

1.9. Communications

There was no communication between the helicopter and air traffic control services.

1.10. Take-off point information

The take-off during which the accident occurred (referred to here as the "second take-off") was carried out from the center of the city of Móstoles' bullring. The bullring, at an altitude of 661 m (2169 ft) above sea level, is located on the outskirts of the urban area, and adjacent to the western side of the bullring there is a large dirt area used as a parking zone for trucks, the northern end of which was empty on the day of the accident.

The interior, ground level area of the ring consists of a compact earth surface in a circular shape with a radius of 24m, enclosed by a wooden barrier measuring 1.6 meters high (see Appendix 1).

Around said barrier and at a radial distance of 1.6m are the stands, which reach their highest point on the western side, there measuring 14m high and standing 48 m from the center of the ring. The lowest part of the stands is located on the eastern side, where they reach a maximum height of 6m and stand 34 m from the center.

In the latter area the building's enclosure wall stands 3m high and 44m from the center of the ring.

Adjoining the lowest area of the stands and to their right, looking from the center of the ring, is a structure designed to serve as a stage, measuring 10.5m high and with a facade measuring 13 m in length.

The helicopter was resting inside the bullring in the area closest to the facility's lowest side, with the forward end of its skids located 3m from the center of the ring, and the rear end of the helicopter's tail at a distance of 10 m from the barrier (see Figure 1).

1.11. Flight recorders

The helicopter was not equipped with flight recorders, as they were not required for its type.

1.12. Wreckage and impact information

In its descent the helicopter struck the upper right of the building's exterior wall, with the skids and the undercarriage, main rotors and tail rotors, and the aftmost section of

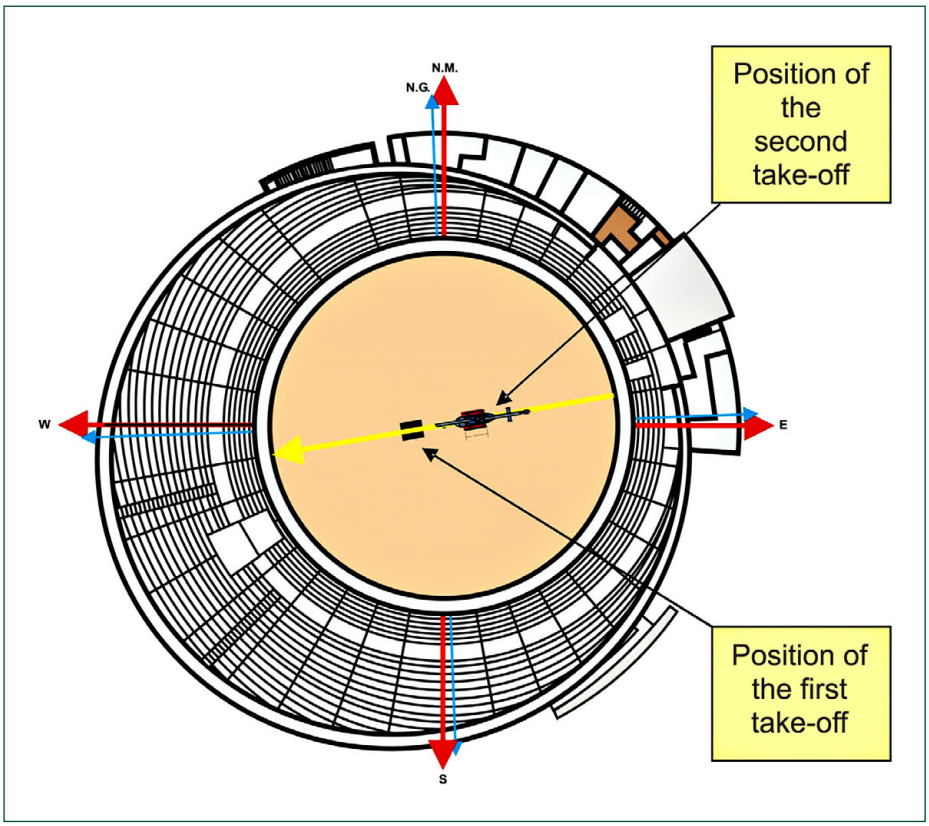


Figure 1. Overhead view of the bullring

the tail cone. It impacted the ground with the skids, and then turned over onto its left side. Throughout this process the helicopter continued its rightward turn around its vertical axis.

The original tracks produced by the impact of the skids and main rotor were found on the ground.

The passenger area of the cabin showed warping and some broken glass. The skids were detached from the helicopter. The tail cone was severed and physically separated at its center, and the tail rotor was separated from it. The main rotor blades were broken in multiple locations and separated from the helicopter, just centimeters from their root. The mast revealed breakage at the outlet of the transmission gear box, and was separated from it, while the pitch control rods were found broken and separated from the structure.

The powerplant, consisting of two engines and their output reduction gear boxes up to the main gear box, and the box itself were found in proper position and did not reveal any external damage.

The output reduction gear shaft on number 2 engine spun freely, without turning the gears on the main box, while rotating the shaft on the number 1 engine did turn the gears on the main box.

1.13. Test and research

1.13.1. *Television footage*

The helicopter's take-off and subsequent crash were filmed on video by different media sources. The footage was shot from both outside and inside the helicopter.

Analysis of the images and sounds captured on the footage has provided information relevant to the investigation.

1.13.1.1. Study of the sound

On the video footage taken a decrease in the volume of the noise generated by the aircraft could be detected. As a result, laboratory analysis of the sound was carried out.

The audio data analyzed were taken from a video filmed from the interior of the aircraft. 17 seconds were analyzed, from the point at which the helicopter began to leave the ground until it disappeared behind the bullring wall. The conclusions reached were the following:

In the first six seconds of the sound analyzed, the functioning of the different systems matches the helicopter's flight attitude, and no discrepancies in the functioning of the different systems can be noted.

As of the sixth second the following can be heard:

- A clear and smooth drop in the revolutions of the following systems:

  – Main rotor box, input reduction gear
  – Tail rotor box, input reduction gear
  – Main rotor
  – Tail rotor

The main rotor's RPMs dropped, reaching a reading below 70%.

The audible warning alarm for low main rotor RPMs was not detected in the review of the videos, nor could it be identified in the analysis of the sound. Ground testing subsequently confirmed the correct functioning of the alarm horns.

1.13.1.2. Study of video footage

The footage was analyzed from engine start-up until the completion of the helicopter's evacuation.

The time elapsed between the initiation of engine start-up and the take-off was two and a half minutes. During this time the pilot did not perform a static power test.

The take-off was executed with a vertical ascent off the ground and a gradual rightward turn until reaching, between 5 to 7 seconds after losing contact with the ground, an approximate altitude of 5 m (15 ft) and an approximate northerly heading, when the helicopter reduced its ascent and rightward turn rate until almost ceasing both of these movements, and immediately increased its ascent and rightward turn rate until reaching an approximate altitude of 8 m (25 ft) above the ground and an approximate heading of 045°, at the same time initiating a forward movement that continued until the aircraft crossed over the stands, and initiated a virtually vertical drop.

At the start of the helicopter's forward movement, and when it was still located above the earth area inside the ring, it began a slight leftward tail yaw (with the nose moving rightward), then increasing its turn rate while moving forward a few meters, and during its drop.

Outside the ring, the helicopter came to rest turned over on its left side. The engines continued to function until they were shut down at least 25 seconds after the crash.

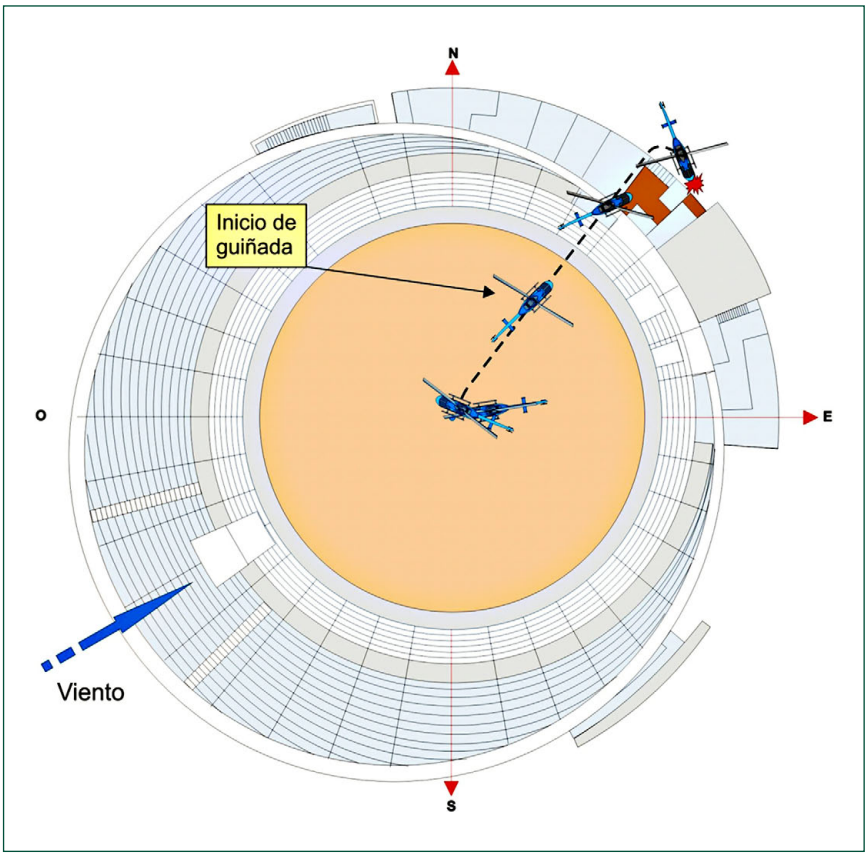


Figure 2. Trajectory of the second take-off (inicio de guiñada = initiation of yaw)

1.13.2. *Detailed inspection of the aircraft's components*

1.13.2.1. Quad Digital Digital Indicator (QDI) Instrument

The QDI instrument gives an indication of engine parameters corresponding to the turbine outlet temperature (TOT), N1, and oil temperatures and pressures. It features the possibility of processing fuel consumption information and showing and storing any exceedance readings of the parameters as related to both engines.

The visible information on the QDI represents redundant information for the pilot, given that this information is readable on the corresponding analog instruments.

The QDI is an optional instrument and the minimum equipment list (MEL) indicates that the helicopter can fly with the instrument not installed or inoperative.

The QDI instrument installed in the helicopter was not in working order. As a result, the possible exceedances recorded by it could not be obtained.

1.13.2.2. Inspection of engines

Laboratory sound analysis revealed different behaviors in the two engines: while in engine no. 1 a drop was initiated in the rate of the gas generator, (N1), on no. 2 this rate continued to increase, and a drop began several seconds later. For this reason, it was deemed necessary to carry out an engine test in a bench test facility, with the manufacturer's assistance.

Both engines were disassembled from the fuselage with the help of the operator and transferred to facilities in an authorized maintenance center where they were bench tested

The inspection of both engines showed intake damage and erosion in the blades of the first stage of the compressor. Both spun freely and smoothly. No additional, visible damage was detected on either of the engines, and they were judged to be capable of functioning in the test facility just as they were recovered after the accident, without any need to repair or substitute any components.

The functional test of both engines yielded a positive result. Engine n° 1 revealed slightly less power than that specified, and n° 2 slightly more than that specified. The bench test confirmed that both engines were capable of producing power sufficient for sustained flight.

1.13.3. Statements from witnesses

1.13.3.1. Pilot's statement

The pilot stated that he arrived at the Cuatro Vientos aerodrome at approximately 09:30 in the morning, in order to complete a routine flight scheduled for approximately 10:00. Moments prior to initiating this flight he was informed by the police officer that was to accompany him on the flight that they would be transporting public figures on that day.

Once in the air, he was informed that the City of Móstoles bullring would be the designated location where the passengers would be embarked, and that the flight would be carried out over said city, with a subsequent landing to be made on property located on the city's outskirts

In order to review the flight itinerary and conduct a practice run, he landed at the bullring on a westerly heading and three persons were embarked. Thus, a total of five persons were then on board. He carried out a power test and took off towards the west. When the helicopter was located above the stands, it turned towards the right and departed the ring, passing over a lower area of the facility.

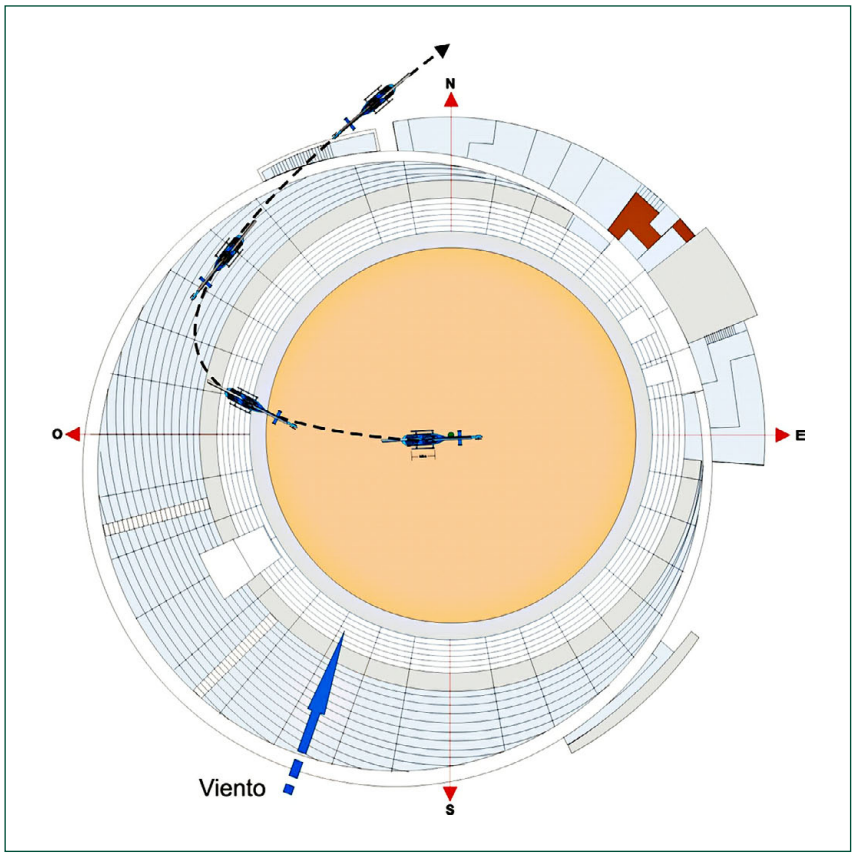


Figure 3. Trajectory of the first take-off (for the practice flight)

Once covering the route of the probable itinerary, he flew for a few minutes in order to consume fuel, so as to reduce the take-off weight. He landed again in the bullring at 11:30, positioning the helicopter as close as possible to the wall located behind the helicopter's tail. He then shut down the engines.

During the waiting period, he was asked about the possibility of embarking 5 persons, which he rejected, agreeing to embark a maximum of four passengers.

In addition, he was informed that the bullring had been selected in order to assure greater isolation for the helicopter at take-off, and that there should be nobody, including the press, inside the ring.

The sandy earth of the ring's ground level was watered down for the first take-off, without him having requested this action.

He reported that he did not remember having received training with regard to the loss of tailrotor efectiveness (LTE) during his initial pilot training, nor in the specific training for ratings on the types he was flying, nor over the course of his career, although he was aware of its existence.

According to his statement, he was occasionally designated for this service, with the objective of completing some flight hours and the proficiency test and competency check on this model, as his renewal was coming up.

1.13.3.2. Auxiliary crew member statement

His mission on board regularly consisted of carrying out tasks of police surveillance, for which he was seated on the left forward seat. He was using a radio transmitter installed in the cabin, which operated via the helicopter's headphones.

His experience on this helicopter and on the mission was 40 flight hours, and he had begun to work with the pilot two days prior to the accident.

He accompanied the passengers while they took their seats, confirmed that their seat belts were secured, closed the doors, sat down and fastened his harness.

He had only received training on the helicopter in issues related to personal safety.

1.13.4. *Analysis of wind effects on the helicopter*

Before the second take-off from the ring, the helicopter was situated facing into the wind. As soon as it initiated its ascent and turned to the right, the aircraft felt the effect of the wind, which was coming from its left. After the first ascent, the helicopter had an approximate heading of 045° and the prevailing wind was from 240°, such that the relative wind direction was from 195°.

1.14. Organizational and management information

1.14.1. *Operator organization*

The operator had extensive experience with the operation of the Bell 206 L4T model helicopter.

Operations with the BESCAM had begun 10 months prior, and with this model of helicopter.

The operator possessed a technical library with information for distribution to pilots. This information included the informative notes and letters published by the manufacturer[4]

[4] The manufacturer of the aircraft had issued the publications Operation Safety Notice (OSN) 206-83-10 in 1983 and the Information Letter (IL) 206-84-41 in 1984 regarding uncontrolled helicopter yaws which, if they do not disappear, may produce a loss of effectiveness in the aircraft's directional control. These publications had been distributed to the operators of their helicopters in order for them to be provided to pilots, so that the latter might know the way to avoid the yaws, and know how to get out of them in the event that they occur.

with regards to LTE (loss of tail rotor effectiveness) that had been distributed within the company in the year 1999 by means of an operational circular[5] to the pilots.

The operator stated that between 1992 and 2004 they had provided recurrent training to flight crews, with the support of Bell flight instructors, and in which the topic of loss of tail rotor effectiveness had been covered.

1.14.1.1. Confined area and maximum take-off

The operations manual included information regarding confined areas in the section on aerial work, but it did not contain detailed operational procedures for the use of confined areas. There was also information on confined areas and maximum take-offs in the Maneuvering Guide[6] of the operator's Bell 206 Captain's Course.

As stated above, the operations manual defines a confined area as a section of land surrounded at its perimeter by obstacles that require the use of special techniques to land and take off.

When the use of these types of areas is necessary, the operator's operations manual literally states "the need to strictly follow all information provided as regards operating procedures in "CONFINED AREAS," the observance of which will prevent a great number of accidents". However, those procedures did not appear in detail in the manual, and it is in the Maneuvering Guide of model Bell 206 where it is stated, for example, that the take-off required in this type of operation is that referred to as "maximum take-off", which is to be carried out in those cases in which, due to the proximity of obstacles, a normal take-off can not be executed.

The requisites included in the Guide for this type of maneuver are:

1. Constant heading and a straight flight path. Vertical climb.
2. Until clear of the obstacle:

   - Attitude of 45 knots
   - Apply more power than that necessary to hover:

     – 3% of N1
     – 10% of torque

3. Once clear of the obstacle, adjust velocity to 60 kt and adopt an ascent rate 500 ft/min.

[5] The operational circulars, together with the information circulars, are documents established within the operator's organization to provide crews with information.
[6] Document of the operator used as didactic material for flight crew training.

and the guidelines established in the Guide for this type of maneuver are as follows:

> "Determine the power level to be employed during take-off. From the ground, increase the collective smoothly and continue until obtaining the selected power level, coordinating with the pedals in order to maintain heading and vertical ascent. Upon clearing the obstacle, adjust nose attitude as determined by normal ascent speed, and apply drift correction in order to maintain the straight flight path over the ground, conserving the take-off power level.
>
> Once this speed is reached, stabilize it and adjust power so that the climb rate is appropriate."

1.14.1.2. Form for calculation of weight and balance

The operator's operations manual included a weight and balance form.

At the time of the accident there was no form for the calculation of weight and balance on board the helicopter. The pilot reported that, once the number of passengers was known, he had completed a calculation of approximate weight for the second flight, estimating the fuel amount on board at 350/400 lb.

In the operator's documents for the execution of recurrent training or pilot competency checks, there was no mention regarding the confirmation of weight and balance.

1.14.1.3. Flight training

The operator's operations manual includes a recurrent flight training program, calling for a minimum of 1h every 12 months, which may be combined with the competency check. In said program the main failures of helicopter systems are outlined, and the procedures associated with them. The instructor is to have 500 h of experience on this type of helicopter.

In the pilot's flight log, two competency check flights had been recorded in the Bell 206 4LT helicopter during the last twelve months, one on July the 23rd and another on November the 29th. The recurrent flight training was the same as the competency check in July and the total duration of the flight was two hours.

The proficiency check tests completed in the last two years were reviewed, and no maximum take-offs or any under any maximum conditions could be verified. To document maneuvers the operator used as a log a single list of procedures and maneuvers for "FLIGHT TRAINING" AND "PROFICIENCY VERIFICATION." On said list it

was observed that in the last two years, of the four types of take-off carried out in both tests, normal take-off and maximum take-off weight (real or simulated) appeared repeatedly.

1.14.2. *Client communications with the operator*

The operational communications regarding the daily scheduling of the flights, between the client and operator, that is, between the BESCAM Coordination Center and the helicopter pilot, were normally conducted by telephone. Nevertheless, the information concerning this flight transporting VIPs was transmitted by the auxiliary crew member to the pilot moments before take-off.

The Technical Specifications Document that governed the contracting of helicopter service by the BESCAM, of 29 October 2004, indicated that the mobilization of the helicopter was to be exclusively carried out from the Coordination Center, wherever established. The Coordination Center would communicate the place and type of mission that would affect the flight at hand to the staff in service, with the objective of allowing them to acquire the equipment necessary for the provision of the service. The Center had 10 months of experience in operations with helicopters.

1.15. Additional information

1.15.1. *Loss of tail rotor effectiveness*

1.15.1.1. Description

The loss of tail rotor effectiveness is a critical flight characteristic of all those helicopters designed with one main rotor and flying at slower than 30 kt (55 km/h). LTE can result in an uncommanded yaw and with a very rapid spin rate. Said characteristic does not go away by itself. Thus, rapid action by the pilot is necessary in order to correct it, and it can render the helicopter uncontrollable.

In helicopters whose main rotor spins counter-clockwise, the yaw produced will cause the nose to turn rightward. The loss of effectiveness may appear in maneuvers at high power and low speed with tail winds or cross winds from the left. The aircraft is more susceptible to this phenomenon when turning to the right.

The following four characteristics have been identified[7] as factors contributing to the production of LTE during the flight of a helicopter (whose main rotor spins to the left)

[7] See FAA Advisory Circular AC 90-95 "Unanticipated right yaw in helicopters".

when flying at low speed. Wind plays a crucial role, depending upon its intensity and its direction relative to the aircraft.

- The loss of translational lift[8] with winds from all directions produces an increase in power needed, and the consequent increase in anti-torque demanded of the tail rotor. With a power level close to maximum, an increase in power can result in a drop in the main rotor's (Nr) revolutions, and, consequently, in a drop in thrust from the tail rotor.
- The interference from the vortexes produced by the main rotor with winds blowing from the region between 285° and 315° (taking as the vertex the center of the helicopter and its longitudinal axis forward as the initiating side of the sector, spanning out to the right) on the flow of air on the tail rotor alters the thrust effect from this rotor, as it is operating in a very turbulent environment.
- Tail winds proceeding from the region lying between 120° and 240° (see Figure 4) can produced a weathervane effect on the structure of the helicopter, causing a yaw into the wind, or the acceleration of an established spin rate.
- The winds proceeding from the region between 210° and 330°, as they oppose the thrust generated by the tail rotor, can generate a "vortex ring state"[9] causing a destabilized flow and oscillation in thrust generated by the tail rotor. This is why rapid and continuous pedal movements are necessary when hovering in crosswinds from the left.

The following factors can also seriously affect the appearance of LTE:

- High gross weight and density altitude. An increase in either of these factors will decrease the power margin between the maximum power available and the power required to hover. The pilot should conduct low-level, low-airspeed maneuvers with minimum weight.
- Low indicated airspeed. At airspeeds below translational lift, the tail rotor is required to produce nearly 100 percent of the directional control. If the required amount of tail rotor thrust is not available for any reason, the aircraft will yaw to the right.
- Power Droop. A rapid power application may cause a transient power droop to occur. Any decrease in main rotor rpm will cause a corresponding decrease in tail rotor thrust. The pilot must anticipate this and apply additional left pedal to counter the main rotor torque. All power demands should be made as smoothly as possible to minimize the effect of the power droop.

[8] Translational lift. The additional lift obtained in forward flight owing to the greater efficiency of the rotor system (see FAA-H8083-21 "Rotorcraft Flying Handbook.")

[9] "Vortex ring state." A temporary situation in which the rotor passes through its own wake and a significant part of the blades operate at attack angles in excess of maximum. The blade tip vortices increase in size until they form a ring around the rotor. There is a turbulent, unstable flow in a large area around the rotor disc which causes the rotor to lose efficiency, even if it continues to receive power. On the main rotor the "vortex ring state" may occur in vertical descents at high power (see FAA-H8083-21).

As a result, pilots should be conscious of those situations in which LTE may occur in order to avoid them, in the event that the tail rotor loses effectiveness, and in order to be aware of the actions to take in order to escape from this critical situation, given that the aircraft can not correct this situation on its own. These actions should be taken quickly and correctly. If they are not, recovery from LTE can become impossible. The recommended techniques, according to the FAA's AC 90-95, are:

- Apply full left pedal. Simultaneously, move cyclic forward to increase speed. If altitude permits, reduce power.
- As recovery is effected, adjust controls for normal forward flight.
- Collective pitch reduction will aid in arresting the yaw rate but may cause an increase in the rate of descent. Any large, rapid increase in collective to prevent ground or obstacle contact may further increase the yaw rate and decrease rotor rpm.
- The amount of collective reduction should be based on the height above obstructions or surface, gross weight of the aircraft, and the existing atmospheric conditions.
- If the rotation cannot be stopped and ground contact is imminent, an autorotation may be the best course of action. The pilot should maintain full left pedal until rotation stops, then adjust to maintain heading.

1.15.1.2. Other accidents or incidents related to the loss of tail rotor efffectiveness

Between 1998 and 2005, both years included, 16 civil helicopter accidents occurred in Spain in which the probable cause was loss of flight control. In seven of these cases, the probable cause of said loss of control was LTE.

The CIAIAC presented information on the LTE phenomenon in its reports A-028/99 (Bell 206L4, 22-07-1999), A-030/2000 BIS (Bell 205(UH-1H), 04-08-2000), IN-066/2002 (Robinson R-22, registration EC-GVR, 07-09-2002), A-043/2003 (Bell 206-L3, registration D-HALT, 6-8-2003) and in A-74/2004 (Robinson R-44, registration EC-ITD, 20-12-2004).

The accident report (reference A-43/2003) involving an helicopter of this operator, includes the following paragraph: "Due to the importance that unexpected yaws or losses of tail rotor effectiveness represent as contributing factors in a number of accidents, knowledge of the circumstances which favor their appearance is important, as are ways of preventing them, and how pilots should react if the yaw has been initiated."

In July of 1994 the National Transportation Safety Board (NTSB) in the United States of America issued three safety recommendations (NTSB references A-94-139, A-94-141 and A-94-140 respectively) addressed to the FAA in reference to the need for helicopter pilot education and training in order to prevent future accidents caused by this phenomenon.

Recently, other accident and incident Investigation commissions such as the British AAIB[10] and the Irish AAIU[11] have issued a number of recommendations[12] in order to raise awareness of this phenomenon among operators and pilots, including the necessity of including the LTE effect in pilot education programs published by the JAR-FCL 2.

1.15.1.3. Pilot education

The syllabi for the theoretical knowledge exams are a part of JAR-FCL 2 in force in Spain since 2004 (published in the BOE on 22 November 2004), and they do not specifically mention the term LTE. This concept was also not included in the programs previous to the entry into force of JAR-FCL 2.

However, the LTE was specifically mentioned in the training syllabi included in Section 2 of JAR-FCL 2, among the acceptable means of compliance (AMC) with the requirements, which had not been published in Spain.

2. ANALYSIS

2.1. General

The aircraft had taken off from the Cuatro Vientos aerodrome, with the pilot and police officer, a member of the BESCAM, on the first flight of the day in order to head for the city of Móstoles, with the objective of transporting public figures. The pilot was informed of this mission the same day, and it was proposed that he use the city's bullring to embark the figures, to which he agreed.

In Móstoles he landed in the bullring and three more persons embarked in order to complete a flight that would simulate the subsequent official flight for the transport of the public figures in question. According to an estimate carried out after the fact, the helicopter took off towards the west, carrying approximately 115 kg of weight in excess of the authorized maximum. When it reached a point over the stands, it carried out a rightward turn and left the ring over its lowest point. The flight consisted of a practice run to reconnoiter the route to follow when transporting the public figures, and for the selection of the landing area. The helicopter touched down in El Eliana Park where three persons disembarked. The pilot and the auxiliary crew member continued the flight, returning to the bullring. The pilot deemed it expedient to prolong the flight in order to consume more fuel, given the weight conditions forecasted for the upcoming take-off, and landed again in the ring at 11:30 h.

[10] Accident of a Bell 206B Jet Ranger III, G-BAML on 30 May, 2003. Final Report EW/C2003/05/07. Accident involving a Robinson R44, G-SYTN on May 8, 2005. Final Report EW/G2005/05/07.
[11] Accident involving a Bell 206 Jet Ranger, G-AYMW on April 5, 2004. Final Report No. 2004/0021.
[12] Safety recommendations 2003-126 and 2003-127 of the AAIB United Kingdom and SR 39, 41, 42 and 43 (year 2004) of the AAIU of Ireland.

Once the four passengers for the official flight for the transport of public figures were seated in their respective seats and their seat belts were secured, the auxiliary crew member issued them some safety guidelines. The total number of persons on board was six. The weight of the helicopter for that second take-off has been estimated at 2,222 kg (4,899 lb), that is, some 159 kg over the authorized maximum.

During the take-off there was an initial power demand from the pilot that resulted in the helicopter's vertical ascent for six seconds, reaching an approximate altitude of 5 m (15 ft) while it turned to the right. At this point, the pilot made a second power demand until reaching a torque value of 100%, which resulted in a slowdown in the rightward turn, as the aircraft continued its ascent until reaching an approximate altitude of 8 m (24 ft), and initiated forward movement.

Seconds later the helicopter initiated a smooth, leftward tail movement to (nose to the right) and the turn rate began to increase while the aircraft moved forward. Once it crossed over the ring's stands, the helicopter turned, out of control, and went into a rapid descent until hitting the ground.

2.2. State of the aircraft

At the moment it initiated its take-off, all the helicopter's engine and rotor parameters were in line with necessary power requirements. In the investigation following the accident, damage was noted to the engines, power transmission mechanisms, rotors and flight control systems were in line with the impacts suffered by the aircraft. Thus, there was no evidence leading to any suspicion of mechanical failure in its power or transmission systems. Following the analysis of the sound of the main rotor, it is considered that the behavior of the tail rotor was continually matched to that of the main rotor. Thus, its drop in revolutions was proportional.

Once the engine stand tests were completed, the possibility of any anomaly in their functioning was ruled out, and it is considered that the difference in their behavior was owing only to their slight differences in adjustment and state, but that both were in normal functioning condition.

The aircraft initiated the takeoff with an estimated weight of 2,222 kg, which was 159 kg over the MTOW, or established limit in the Flight Manual, 2,063.5 kg. The helicopter had already carried out a previous take-off, from inside the ring, with a westerly heading and a weight of 2,178 kg (4,802 lb), 115 kg over the MTOW.

No weight and balance form was found in the helicopter. For this reason, a safety recommendation is issued for the operator to assure that crews carry clear information on board in order to easily and quickly determine the helicopter's weight and balance, and that they use it systematically.

2.3. Communication to the pilot regarding the flight

The communication to the pilot of the special flight characteristics was carried out by the municipal police officer when he reached the Cuatro Vientos aerodrome, minutes before initiating the first flight of the day. The Technical Specifications Document which governed the contracting of the helicopter mandated that the communication be carried out through the Coordination Center, and with sufficient advance warning to allow for adequate flight preparation.

This tardy communication to the pilot regarding the characteristics of the flight for the transport of public figures, which would require the helicopter to be filled to capacity, and which would involve an unusual operational environment could have influenced the pilot's operating decisions, and reduced the time available to him for their preparation and planning.

2.4. Crew experience

The pilot had extensive experience on single-engine helicopters, while his experience on twin-engine models was limited to the Bell 2064LT. Over the preceding year he had flown this helicopter for a total of 34 h, which had been irregularly distributed throughout the period, because most of the hours had been flown during the first six months (see Graphic 1).

His experience with the BESCAM Helicopter Service was two days. He had been provisionally appointed in a substitute role.

In July 2005 he had flown for two hours in a proficiency check and recurrent training flight. He had completed his competency check flight for the renewal of his type rating on the Bell 206 4LT on 29 November, 2005, within this substitution period. No evidence has been found that during that set of check and training flights they carried out maximum take-off practice maneuvers, which were considered demanding and advanced flight maneuvers.

The auxiliary crew member had no role with regards to the operation of the aircraft, and thus had not received any education in this regard.

2.5. Confined area

The helicopter is capable of vertical ascent and clearing nearby obstacles, although in these cases reaction capacity is reduced in the event of any difficulties, as the aircraft's technical capabilities are being fully exploited.

The distances and heights at the Móstoles bullring classify it as a confined area, and the prevailing wind at the time of the flight increased its confinement, as it demanded a take-off over its highest point.

The selection of a confined area for a take-off decreases available safety margins, as there are barely any obstacle-free areas in which to carry out a commanded landing in the event of failed take-offs or a forced landing in the event of a sudden emergency.

The danger posed by confined areas is outlined in the operator's Operations Manual for the helicopter, and mandates that pilots strictly observe all information provided in the operating procedures regarding "CONFINED AREAS." Nevertheless it is lacking a more complete description of the obstacles and heights defining said areas, their characteristics, an assessment of the risks they pose, and the procedures to be followed when dealing with them.

2.6. Loss of tail rotor efectiveness (LTE) during the second take-off executed from the bullring

The helicopter was situated facing into the wind, with a heading of 250° and positioned near the center of the ring before proceeding to carry out the take-off which ended in the accident.

The pilot did not complete a power check prior to take-off, although he did report that, though he did not remember the exact figures reached, when initiating the take-off he applied the necessary power, in line with the figures determined in the test of the first take-off.

Said power level was only capable of providing lift for the first six seconds, after which the pilot had to apply more power in order to continue his ascent, maxing out the collective stick, according to his statement and all the information analyzed, which led to a drop in his turn rate to the right, until virtually halting it. The torque reached and exceeded 100%, according to his statement.

With the modification made to the Bell 2064LT, a single-engine helicopter of 500HP of power, consisting of the installation of two engines via an STC, practically doubled the power (450HP of power from each engine) available in the structure of the helicopter, although the application of power in practice continued to be limited by the different mechanical systems of the power transmission gearbox and the rotors, both main and tail.

Upon abruptly demanding maximum power from the helicopter, with a weight on board in excess of the MTOW, a reduction in the number of rotor turns was produced, as could be detected in the sound analysis, as well as an increase in the helicopter's reaction torque.

At that time, great efficiency was required of the tail rotor in order to counteract the torque produced.

When the helicopter had initiated its forward motion, with the objective of increasing speed and prior to crossing over the barrier, it initiated a rightward turn upon its vertical axis, the speed of which gradually increased, until it became uncontrollable.

At this point during the flight, the helicopter was carrying a great amount of weight, was at an altitude near that of hover outside ground effect, a speed below 30 kt, a power demand close to its limit, and was being affected by a tail wind resulting from the initial ascent leg and its commanded right turn.

These conditions which the helicopter faced during this phase of the flight and the subsequent increase it suffered in rightward turn speed coincide with the factors that can produce a loss of tail rotor effectiveness. As a result, it is believed that the aircraft was affected by this phenomenon.

Once a helicopter begins to suffer the effects of the LTE phenomenon, rapid and effective action by the pilot is necessary in order to recover stable flight conditions. In this case the pilot did not identify the LTE affecting the helicopter, and thus did not act to correct it. Even if he had been aware of the method for counteracting it, he was also faced with the limiting absence of obstacle-free areas in his flight area in which to carry out an emergency landing.

The pilot reported that he was aware of the LTE phenomenon, but that he was not aware of its characteristics, and that he did not remember being trained on it, neither in the period for the obtaining of his pilot licence, nor over the course of his career.

On the other hand, the operator stated that they do disseminate information circulars to the crews, among which there were two related to the LTE phenomenon published by Bell and that training had been provided for years since the topic was first covered. Therefore, in view of this information, the effectiveness of those measures and their real impact on the operator's flight crews seems questionable.

The regulations currently in force have been reviewed, as well as other norms not yet published in Spain regarding the training of commercial and private helicopter pilots (JAR-FCL-2, Section 1 and Section 2 (AMC)). The syllabi of the theoretical knowledge exams are a part of JAR-FCL 2 published in Spain in 2004 (BOE dated 22 November 2004), and they do not specifically mention the LTE phenomenon. However, it is referred to in the training syllabi of Section 2 of JAR-FCL 2, among the Acceptable Means of Compliance (ACJ) with the requirements.

Therefore, it is considered necessary to issue a safety recommendation to include this LTE phenomenon in the training programs of helicopter pilots in Spain through the publication of the above mentioned syllabi.

The LTE phenomenon, known for many years and about which much information has been published, has been shown to be one of the operational factors which has played a role in numerous helicopter accidents. In addition, it has been demonstrated that pilot knowledge of the causes that generate it decreases the probability of pilots placing the helicopter in conditions rendering it vulnerable to suffering LTE, and increases the probability of recovering controlled flight attitudes in the event that they suddenly experience this situation.

The inclusion of studies of the LTE phenomenon in the theoretical knowledge for the obtaining of private, commercial or airline helicopter pilot licences, requires that it be included as an item within the study of the tail rotor. Pilots who have already obtained their helicopter pilot's licences could be distributed at least part of the abundance of information already published on this phenomenon. To this end, two safety recommendations are issued in this regard.

3. CONCLUSION

3.1. Conclusions

Regarding the functioning of the aircraft and its systems

3.1.1. No evidence of any mechanical failure or malfunctioning of the aircraft's systems which might have led to the accident was discovered.

3.1.2. A bench test of the engines conducted after the accident confirmed that both engines were capable of producing power sufficient for sustained flight.

Regarding operational aspects

3.1.3. The pilot was informed that same day that he would have to carry out a transport flight of public figures, and that the take-off would be conducted from a bullring. This advance notice may have been insufficient to allow him to adequately prepare for the flight.

3.1.4. The BESCAM Coordination Center had selected the site and proposed to the pilot the take-off from inside the bullring. The pilot did not object to this point, despite the fact that there was a clear area of sufficient size adjacent to the bullring.

3.1.5. The pilot's decision to accept the take-off from the bullring may have been influenced by the importance the flight took on given that he was to transport public figures and that print press and television crews were present in the area.

3.1.6. The helicopter took off twice with a weight calculated to be above the limit established in the Flight Manual, and the aircraft was not carrying weight and balance sheets in order to quickly and easily complete the relevant calculations.

3.1.7. It is estimated that the helicopter was carrying a weight of 2,222 kg at the time of the accident flight, that is, approximately 159 kg in excess of the maximum authorized weight.

3.1.8. The take-off was carried out over the lowest area of the stands, in such a manner that the wind struck the helicopter from its tail.

3.1.9. During the take-off of the accident flight, a constant heading was not maintained. A rapid demand for great power was made, after which a drop in power occurred, with a decrease in the main rotor's rotation speed.

3.1.10. The helicopter was facing the following conditions at the instant in which its initiated its rightward nose yaw:

- Demand for maximum power
- Weight in excess of the MTOW
- A near hover and leaving ground effect
- A drop in rotor rotation
- A tail wind, within an arc defined between 120° and 240°

3.1.11. The pilot could not have recovered the tail rotor's effectiveness by lowering the collective, as he did not have sufficient physical space in which to carry out an emergency landing and abort the take-off.

3.1.12. The operator's Operations Manual included a description of confined areas, but without outlining their characteristics as regards the obstacles and heights that define them, the risks they pose, and the procedures to be taken when dealing with them.

3.1.13. There were no records showing that the pilot had carried out take-offs under maximum conditions during the last competency checks and the last recurrent training.

3.1.14. The pilot did not remember having received specific education regarding the LTE phenomenon.

3.1.15. The JAR-FCL 2 training programs to obtain private and commercial helicopter pilot licenses do not specifically cover the LTE phenomenon. It is, however, included in the syllabi that further expand those programs and that form a part of the acceptable means of compliance with JAR-FCL 2.

3.1.16. The operator had transmitted within its operations department the information issued by the manufacturer regarding the LTE phenomenon.

3.2. Causes

Given that the helicopter was carrying weight in excess of the authorized maximum at take-off, speed below 30 kt, an approximate altitude of a hover out of ground effect, maximum demand for power, and a relative wind striking the aircraft at an approximate angle of 195º when it spun out of control to its right about its vertical axis, it is considered that the probable cause of the accident was the loss of tail rotor effectiveness (LTE), which caused the loss of flight control and the helicopter's subsequent crash.

It is considered that the following factors contributed to generating the conditions under which the LTE occurred:

a) The selection of a confined area (the bullring) as the take-off site.
b) The communication of the flight's special characteristics with little prior notice, which impeded a more thorough preparation of the flight.
c) The pilot's limited knowledge of the LTE phenomenon.
d) The failure to observe the aircraft's weight and balance procedure prior to take-off and the initiation of flight with a weight in excess of the MTOW.
e) The lack of actual training in take-offs at maximum power during the pilot's competency check and recurrent training flights.

4. SAFETY RECOMMENDATIONS

With the objective of improving safety in helicopter flight operations, the following safety recommendations are hereby issued:

REC 20/07. It is recommended that the Dirección General de Aviación Civil (DGAC) [Spain's Civil Aviation Authority] include the concept of loss of tailrotor effectiveness (LTE) in training programs for the obtaining of helicopter pilot licenses through the publication of the syllabi accepted in the framework of JAR-FCL 2.

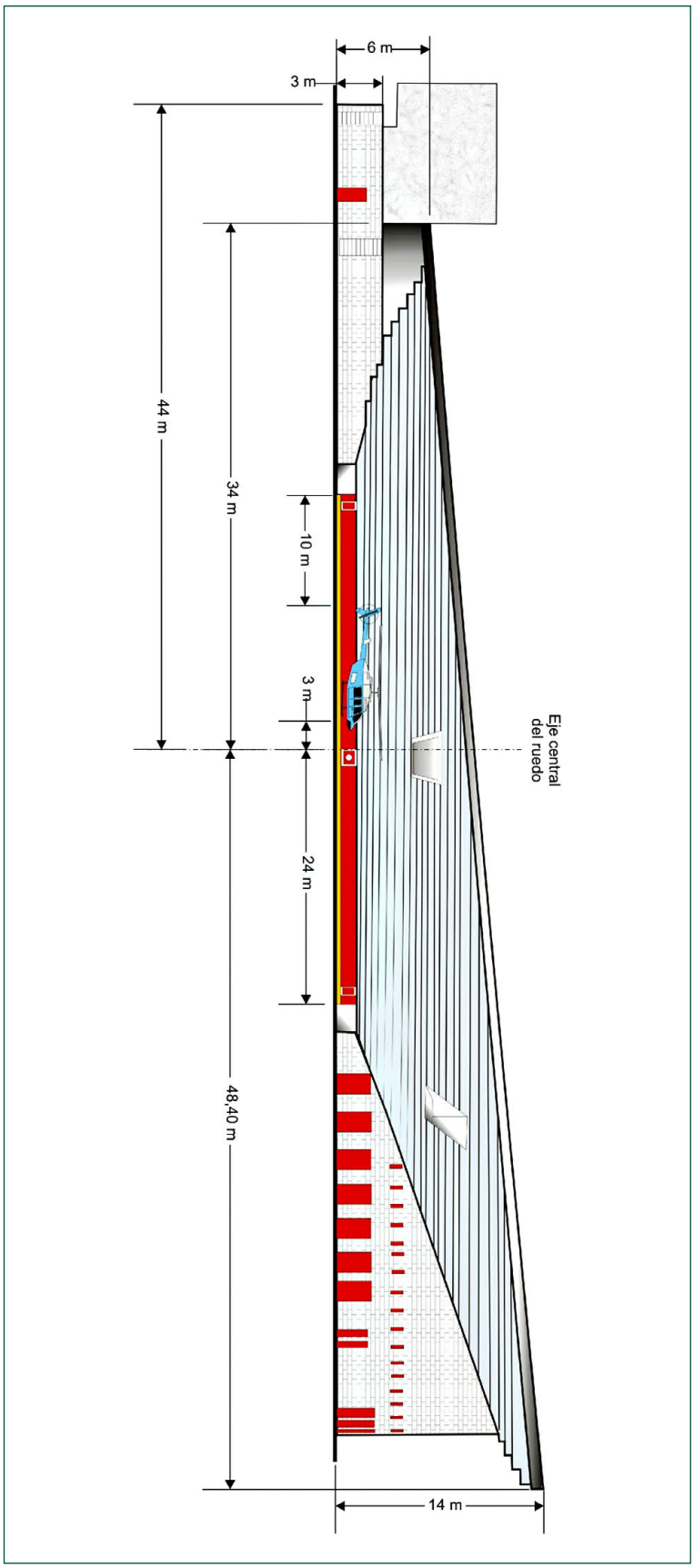
REC 21/07. It is recommended that the Dirección General de Aviación Civil (DGAC) distribute information regarding the LTE phenomenon to all helicopter operators, flight schools, recreational flight groups, and private helicopter owners.

REC 22/07. It is recommended that the Dirección General de Aviación Civil (DGAC) require the helicopter's operator, Helisureste S.A, to adopt measures

assuring that its flight crews carry on board their helicopters all the information necessary to quickly and easily carry out weight and balance calculations.

REC 23/07. It is recommended that the helicopter's operator, Helisureste S.A. revise their Operations Manual to include a more comprehensive description of the obstacles and heights which define confined areas and the procedures to be taken when dealing with them.

APPENDIX 1
Side view of the Móstoles bull ring


6 m
3 m
44 m
34 m
10 m
3 m
Eje central del ruedo
24 m
48,40 m
14 m