DATA SUMMARY

LOCATION

Date and time	**Thursday, 6 October 2005; 13:30 local time**
Site	**Collado La Segueta-Rioseta in Canfranc (Huesca)**

AIRCRAFT

Registration	**EC-ILD**
Type and model	**EUROCOPTER AS 350 B2**
Operator	**Heliswiss Ibérica, S. A.**

Engines

Type and model	**TURBOMECA ARRIEL 1D1**
Number	**1**

CREW

Pilot in command

Age	**58 years**
Licence	**Commercial Helicopter Pilot**
Total flight hours	**10,000 h**
Flight hours on the type	**1,090 h**

INJURIES

	Fatal	Serious	Minor/None
Crew		**1**	
Passengers			
Third persons			

DAMAGE

Aircraft	**Destroyed**
Third parties	**None**

FLIGHT DATA

Operation	**Aerial work – Commercial – Construction/Sling load**
Phase of flight	**Manoeuvring**

REPORT

Date of approval	**30 January 2008**

1. FACTUAL INFORMATION

1.1. History of the flight

The helicopter was carrying out a series of aerial work flights, consisting in the transport of metal netting which were to form part of a protection system to be installed for the prevention of avalanches on a mountain near Canfranc (Huesca). For this purpose the aircraft was carrying a short sling measuring approximately 4,5 m in length, attached to a barycentric cargo hook. To the end of this sling were attached two chains of 3 m in length. At the end of these a metal bar was in turn attached, maintained in a horizontal position. At the ends of this bar were two hooks on which the nets to be transported were hung. According to the information provided, the helicopter's operating company supplies the sling that is connected to the cargo hook, and the company which performs the work supplies the rest of the cargo system (chains, bar, etc.).

The cargo material was picked up at Coll de Ladrones, at a spot height of 1,536 m, and deposited it at nearby site at the top of the Pico del Águila, at 2,096 m of elevation.

After dropping a load, the pilot initiated a descent towards Coll de Ladrones, with the sling hanging but without any load. Moments later the pilot felt a strong blow in the area of the tail rotor, but did not note any anomalous reactions in the helicopter's behaviour such as vibrations or yaw. Nevertheless, he pressed the button to open the cargo hook in order to release the sling. After this, he performed a check of the pedals, concluding that he had lost control of the tail rotor; the functioning of the pedals appeared to be complete and normal, but they produced no effect whatsoever on the aircraft´s flight.

The pilot continued the flight at the same speed and power, changing course to his left to head for the neighbouring valley of Rio Seta, which was the area offering the best conditions to execute an approach and landing.

Upon passing over the area dividing the two valleys, the pilot decided to reduce his descent speed, to this end manipulating the collective pitch control. At that moment the helicopter began to spin to the left and out of control, and ended up crashing violently against the North face of the ravine above the Rio Seta.

The pilot suffered severe injuries which required his evacuation by helicopter to a Zaragoza hospital.

1.2. Injuries to persons

The pilot, the only person aboard the aircraft, suffered multiple fractures affecting five vertebrae in the lumbar and dorsal areas, which resulted in spinal damage, and fractures

also in three ribs. On his right hand he broke several bones and tore tendons between his index and middle fingers.

1.3. Damage to aircraft

The impact into the ground was extremely harsh and as a result the aircraft was destroyed.

1.4. Personnel information

Pilot in Command

Age:	58
Nationality:	Spanish
Certificate:	Commercial helicopter pilot
Issue date:	11-11-1969
Expiry date:	21-07-2010
Ratings:	• VFR – HJ • Agroforestry – only fires: Valid until 11-06-2006 • AS350/350B3: Valid until 11-07-2006

Flight Experience

Total flight hours:	10,000 h
Hours on the type:	1,090 h

Recent Flight Activity

Hours in last 90 days:	148 h
Hours in last 30 days:	52 h
Hours in last 24 hours:	10 h
Start of current duty period:	09:00 h
Rest prior to current duty period:	12 h

1.5. Aircraft information

1.51. *Airframe*

Make:	EUROCOPTER
Model:	AS 350B2
Construction Number:	2598
Year of Construction:	1992
Registration:	EC-ILD
MTOW:	2,250 kg

1.5.2. *Engine*

Make:	TURBOMECA
Model:	ARRIEL 1D1

1.5.3. *Airworthiness Certificate*

Date of Renewal:	31-12-2004
Date of Expiry:	31-12-2005

1.5.4. *Maintenance*

Total flight hours:	4,865: 44 h
Date of last overhaul (100 h + 400 airframe hours + 100 engine hours):	28-08-2005 at 4,771:46 h
Hours since last overhaul:	93:58 h

1.5.5. *Flight Manual*

In the aircraft flight manual's chapter on emergencies, two types of tail rotor failures are covered: the loss of rotor thrust and the failure of the pitch control system.

With respect to the first of these, the manual states that the loss of rotor thrust is indicated by a yaw movement to the left (in powered flight) the intensity of which is proportional to the power and velocity of the aircraft at the moment when the failure occurs.

Photograph 1. Area where the aircraft impacted

The manual mentions two different situations in which this emergency can occur: in stationary hovering position or at low speed, this scenario in turn is divided into with and without ground effect; and in forward flight, outlining the following procedures for each case.

- Failure during hovering or at low speed.

  a) In Hover Within Ground Effect. Descend to the ground, lowering the collective pitch control before the speed of the yaw becomes significant.

  b) In Hover Out of Ground Effect. Lower the pitch moderately in order to decrease the torque and simultaneously increase speed.

- Failure in forward flight

  – Reduce power as much as possible, to the minimum level permitting forward movement at a speed which produces wind vane effect. Identify a suitable location for a very steep approach and proceed at a power level allowing the execution of a sensitively coordinated flight.
  – On final approach, shut down the engine and make an auto-rotative landing at the lowest possible speed.

As regards failure of the pitch control system of the anti-torque rotor, the manual outlines the following procedure:

- Establish indicated speed at 70 kt while on level flight.
- Press the hydraulic test button for five seconds and then return to normal position.
- Head for a clear area with a shallow approach, with a slight sideslip to the left. Execute a run-on landing. The sideslip will diminish as the power decreases.

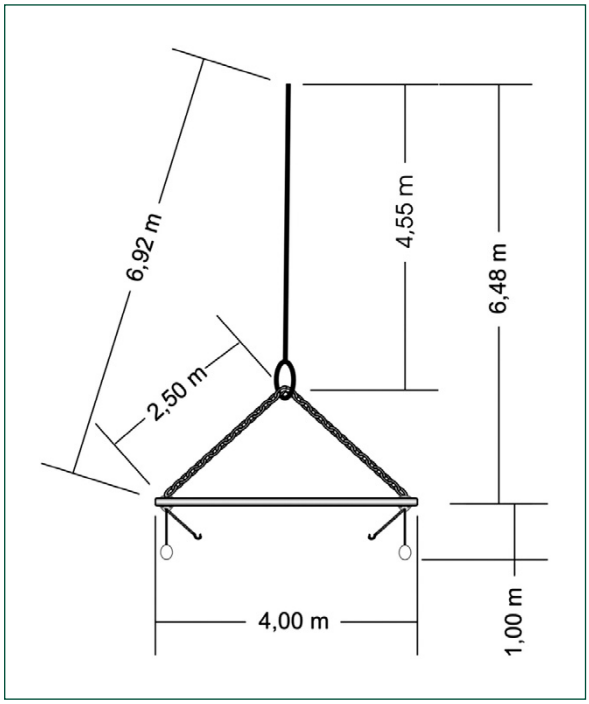

Figure 1. Diagram of the External Cargo Transport Device

1.5.6. *Information on the cargo sling*

The device used to transport the cargo featured the design indicated in figure 1. A 4,55 m sling was attached to the barycentric hook. On the other end of this sling were attached two 2,5 m chains, which in turn held a 4 m metal bar. From both ends of this bar hung two other chains measuring approximately 1 m, to which the cargo was attached.

The entire apparatus measured about 7 m in length.

1.5.7. *Aircraft behaviour following loss of tail rotor thrust*

The aircraft manufacturer's flight test department reported that the two vertical stabilizers outfitted on this aircraft provide an anti-torque effect, whose magnitude is proportional to the aircraft's translational speed, such that at a speed of 50 kt, it is possible to increase power up to 40% without any resulting yaw, and up to 94% torque can be reached at 90 kt.

At a speed of 50 kt, the aerodynamic efficiency of the stabilizers is capable of counteracting the torque required to maintain level flight. If there is a crosswind, however, or if the power required to maintain level flight induces a slight yaw to the right, this may be offset by increasing speed.

The above information is not included in the aircraft flight manual and is not common knowledge among the pilots.

1.6. Pilot's statement

The pilot indicated that the work he was carrying out consisted of carrying metal netting up to the mountain. This netting was attached to the helicopter´s barycentric hook. Once there he was to install it on a series of pre-installed posts connected by steel lines approximately 6 m high. This last operation was carried out by maintaining a hovering position at their same altitude. Workers on the ground then attached one end of the net with shackles previously installed on the steel lines, then attaching the other end, at which point the helicopter was free of any cargo. At this time he would initiate his descent, with

the external device hanging from the aircraft, which did not weigh more than 40 kg. When he arrived to the loading area, the workers stationed there unhooked the trapeze from the sling and attached another, which they already had prepared with the netting.

The reason why he had to bring the cargo mechanism down on each trip was that they only had three of these devices. If they had had more, he could have left them on the mountain each time, later bringing down a number of them on just one trip.

He descended with caution, as he was conscious of the fact that any disruptions could affect the external cargo system.

As regards the meteorological conditions, he indicated that above, where he dropped the cargo, it was not very windy, but below in the Col de Ladrones where he picked up the cargo, it was windier; he estimated wind speeds at about 15 kt. In this area the wind normally comes from the North and is non-hazardous, but on this day it blew from the valley (Canal Roya), from Formigal, that is, from the East. When these conditions arise, some turbulence is generated in the Col de Ladrones area.

He went on to state that just after initiating his descent, he saw the trapeze disappear from the cargo mirror's field of vision, and then immediately felt the trapeze hit the tail rotor. At this time he immediately dropped the trapeze and sling using the electric drop mechanism. At that moment, one of the workers on the ground called him, asking what was going on. The pilot told him not to worry as the helicopter was under his control. At the moment of the impact, it is esteemed that the aircraft's speed was about 50 kt.

He then checked to see if he had control over the tail rotor. He worked the right and left pedals and noticed no response in the helicopter whatsoever. The functioning of the pedals appeared to be normal, given that it ran through its entire mechanical range. The pilot compared the helicopter behaviour to the one produced when performing a tail rotor control failure manoeuvre for rating tests and in training. At no time did the helicopter begin to yaw, nor did the pedals vibrate. In summary, there were no indications from the aircraft that would have led him to believe that the tail rotor had lost power.

Thus, he initiated the manoeuvre as if facing a tail rotor control failure. Familiar with the area, he decided to head toward Rio Seta, the area offering the best conditions to execute an emergency landing with a shallow approach and bleeding off speed due to the steepness of the terrain and the wind, ruling out heading for Jaca.

When he was near the landing area, he began to reduce his descent rate, at which time the helicopter began to spin like a top, faster and faster.

When asked if on the flights previous to the accident flight he had followed the same flight path, the pilot responded that the same path is not always followed, and that on this occasion he might have flown over the steepest area of the slope.

1.7. Meteorological information

The weather forecast for Huesca for the day of the accident called for clouds in the Northeast with possible showers, as well as the possibility of storms. Otherwise slightly cloudy. Light Northerly winds early and from the East later in the day.

1.8. Wreckage and impact information

The helicopter had impacted on its right side against the slope of the Barranco del Rio Seta, which faces Northward and features a gradient of approximately 45°. The aircraft's longitudinal axis came to rest oriented towards the Northeast.

The blades of the main rotor had broken from the impact against the slope, with the marks resulting from the contact clearly visible.

Several of the main rotor mast support bars were also broken, ending up bent forwards.

There was severe damage to the cabin, with the ceiling and left side having disappeared. The pilot's seat was almost totally destroyed, although the part of it that remained inside the cabin showed significant vertical deformation.

The right part of the arches that support the skids had been bent towards the centre of the aircraft, in such a manner that the right skid was practically touching the helicopter´s underside. The left part of the landing gear did not reveal severe damage and had maintained its shape. This deformation was more than great enough in proportion to the grade of the terrain that the aircraft ended up leaning to its right, that is, towards the slope.

Photograph 2. Mark made by a main rotor blade in the ground

The aircraft´s tail had fallen upon a bush. Both tail rotor blades were broken, although one of them was damaged much more severely than the other. Thus, while one revealed damage only to its outer part, the other was totally destroyed from the blade root. A detached piece from this blade was found, fragmented in two, between the branches of a bush located two meters behind the rear of the aircraft. A mark

made by the tail skid was also found in this same location.

The rest of the anti-torque rotor remained in place and it was verified that it spun as normal. The pitch change links were deformed and showed clear evidence of having been hit by a metal object. Nevertheless, despite this damage, the pitch change links were found to function; when the corresponding command bar was activated, the pitch change did respond properly.

Photograph 3. Tail rotor

The tail rotor transmission fairing was dismantled and it was observed that the power axis had broken at one point very close to the joint with the short shaft.

A search was carried out for the device used to hold the cargo to the barycentric hook in the area where the pilot indicated that he had released it. This search was unsuccessful due to the difficult nature of the terrain and the thick vegetation.

1.9. Tests and research

The distance from the spot where the cargo was picked up to the point where it was dropped off measured 1,790 m horizontally and 740 m (2,428 ft) vertically.

According to the information provided by the aircraft's pilot, the descent was carried out adjusted to the grade of the slope, with an elapsed time of approximately one minute. At the moment when he heard the sound the helicopter was flying at a speed of about 50 kt.

So as to estimate the aircraft's parameters during the accident flight, a similar flight was carried out with a helicopter of the same model at an indicated air speed (IAS) of 60 kt which yielded the following results: a TQ reading below 10%, descent rate at 2,300 ft per minute.

1.10. Witness statements

A witness was interviewed who was located on the Eastern slope of a hill that is slightly north of the point where the helicopter hit, and on the same side of the road.

This person indicated that he saw the aircraft fly in a West-East direction and that although he did not notice any unusual sound, it did seem to him that it was flying strangely. He saw it turn to the left, hugging the mountain and shortly afterwards begin to turn to the left upon itself, then immediately crashing into the ground. At that precise time the aircraft´s sound did not seem normal to him. Its fall was straight down and it landed flat, although he was not able to see the final impact because the terrain obstructed his view.

Nevertheless, he estimated that the distance from the point at which the yaw began to the site of the impact was no greater than about 100 m.

1.11. Organization and Management Information

1.11.1. *Operator's operations manual*

The operating company's Operating Manual contains a chapter covering external loads which provides instructions regarding five areas: aircraft equipment, flight characteristics, manoeuvres, instructions to ground personnel and crew ratings.

Only the first three are relevant to the accident discussed here.

As regards the helicopter's equipment, the manual indicates that it is essential that it be equipped with a barycentric hook, in addition to all the necessary attachment devices and containers required to carry out the transport. Moreover, it is to be equipped with one mechanism permitting the opening of the hook and with a second one an independent emergency opener, both of them to be capable of activation by the pilot from the interior of the cabin.

As regards the flight characteristics it states that, prior to flight, the pilot should carry out the following actions:

- Calculate the loads taking into account the performance of the helicopter outside the ground effect and calculate the VNE (never exceed speed).
- Complete a study of the cargo size in each cycle, taking into account conditions: altitude, temperature, wind, cargo zone and power outside the ground effect area.

During the flight itself, the Manual notes that the helicopter may approach its operational limits, in light of which the pilot should take the following into consideration:

- Wind. Avoid swerves without translational lift and towards tail winds.
- Dust. Reduces visibility and lift and may cause problems in motor systems.
- Orography. Should be managed in such a way that there is always an escape route in the event of an emergency. Avoid valleys and closed surroundings when carrying maximum loads.

- Obstacles. Extreme caution should be taken when the operation is carried out near the ground in order to avoid any obstacles that may threaten the safety of the flight, from the ground up to 200 AGL, accounting for the length of the sling used.
- As there exists a variety of tasks involving external cargo, an in-depth study of each operation is necessary which addresses the following factors: the orography at the pick-up and drop-off areas; wind; updrafts and downdrafts; loading and unloading meeting points; study of the helicopter's performance at each place and in each cycle.

Regarding manoeuvres the manual issues the following instructions:

- The cargo is to be lifted vertically, controlling the helicopter's power. The aircraft should immediately be taken to translational lift, whenever possible facing into headwinds and taking care to limit and monitor the cargo's movement and the helicopter's speed.
- Avoid turning and manoeuvring with a full load without translational lift near the ground without ground effect.
- If the helicopter is, or if it turns into a tailwind, extreme caution will be taken when manoeuvring in order to assure translational lift. Cargo drop-off will be carried out carefully controlling the helicopter's power, the distance from the cargo to the ground and the area where the cargo is to come to rest, observing those persons which may be below the helicopter.
- Avoid dropping any cargo if the pilot is not absolutely sure that there is nobody below the helicopter.

1.11.2. *Measures taken by operator*

Following the accident, the operator modified the external loading section of its Operations Manual to include a paragraph providing more concrete instructions on the length of the slings to be used for this type of work, in addition to recommending, insofar as possible, that a cockpit-operated electrically-opening hook be installed so as to facilitate operations and to double as ballast during flights with little or no load.

2. ANALYSIS

2.1. Possible damage sequence

During the inspection of the aircraft wreckage it was noted that the anti-torque rotor assembly (power transmission, control and rotor) revealed two different and localized areas of damage: one on the power transmission shaft and the other on the blades, which broke into several fragments, which were found very close to the aircraft's tail at the impact site.

Photograph 4. Area where the rear anti-torque power transmission shaft was broken

As regards the moment at which this damage occurred, three hypotheses are possible: that both occurred during the flight, that one took place at this time and the other in the final impact with the ground, and, lastly, that both occurred when the aircraft hit the ground.

This last hypothesis is ruled out given that, according to the information provided by the pilot, the first impact had already produced damage to the tail rotor.

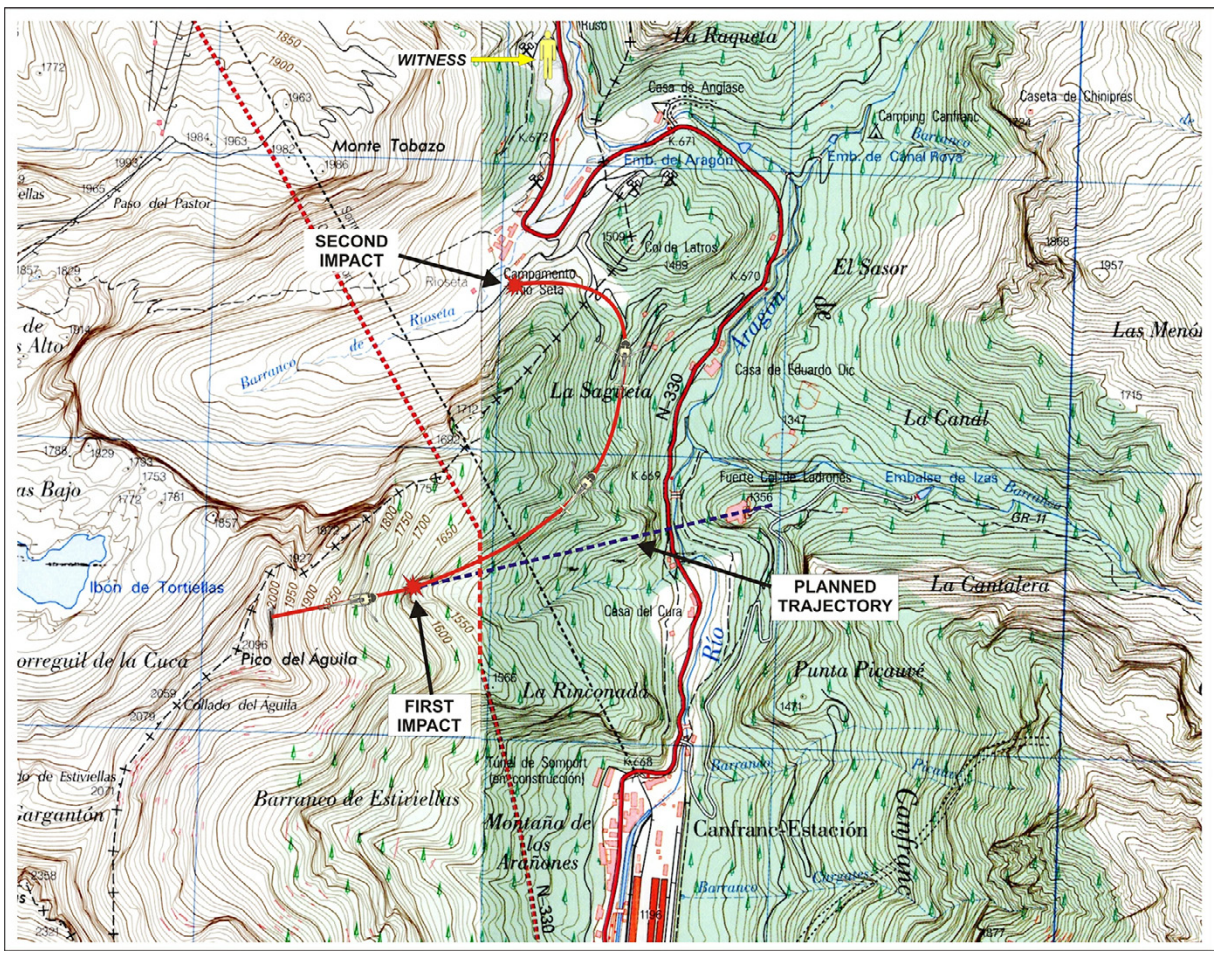

Figure 2. Actual and Planned Trajectories of the Aircraft

In the inspection of the aforementioned wreckage, all the blade fragments were found at less than 2 m from the main rotor, which allows to conclude that they broke in the ground impact; if they had broken prior to this they would not have been found right next to the helicopter wreckage.

In light of the aforestated, it is possible to conclude that the damage to the tail rotor's power transmission shaft must have taken place in the instant when the trapeze holding the external cargo struck the anti-torque rotor. For that reason, the pilot would not receive any response when he worked the pedals given that, though the pitch change was produced, its aerodynamic effect would be nullified given that at the time the rotor was not spinning.

2.2. Analysis: Emergency Management

The emergency arose at the moment when the tool hanging from the sling hit the tail rotor. The pilot, according to his statement, did not notice the possible yaw of the aircraft, nor did he note any change in the helicopter's attitude. After the aforementioned checks performed on the tail rotor controls, he considered that the probable failure affecting the helicopter was the loss of control in the tail rotor and that the rotor continued to spin, producing the same degree of thrust as it had previous to the noted impact.

The aircraft flight manual states that a loss of tail rotor thrust is indicated by a yaw to the left of a magnitude proportional to the aircraft's power and speed . According to the results obtained from the test flight performed following the accident, when the tail rotor transmission broke, the torque being provided by the engine should have been under 10% and the aircraft's speed around 50 kt. Under these flying conditions, very close to those for auto-rotation, the yaw produced when the tail rotor transmission breaks is so low that the effect from the aircraft's vertical stabilizer is more than enough to offset it. Because of this, there was no resulting yaw from this event.

Had the pilot at that moment been aware of the low torque being provided by the engine, and had he known of the vertical stabilizers' aerodynamic effect, in all likelihood he would not have expected the helicopter to yaw sharply as a result of the tail rotor transmission breaking.

Given the conditions in which the aircraft was flying, though, even had the pilot possessed the above knowledge, he had no indications allowing him to clearly discern the nature of the fault he was facing, whether it was a loss of tail rotor control or thrust.

On the other hand, despite concluding that a fault in the tail rotor's control mechanism had occurred, he did not carry out the procedure corresponding to this emergency since

he continued flying under the same conditions, instead of establishing level flight at 70 kt and check how the hydraulic system worked, as required.

On this subject, it should be noted that a correct application of this procedure requires transitioning from flying with a high descent rate and low translational speed to establishing level flight at 70 kt which, given the topography and operations involved, demands specific training if the aircraft is to be positioned in the optimum flying conditions for handling the emergency.

Even so, considering that the performance of aerial work, particularly that carried out in the mountains, normally tooke place in exceptional flying conditions, both operators and pilots should be aware of these circumstances and have procedures ready beforehand and well trained for facing such emergencies.

2.3. Analysis of the Work Practices

In previous sections it has been stated that the first element leading to this accident was the impact of the external cargo holding system against the tail rotor, which most probably broke the power transmission shaft.

Two factors are involved in this strike: the use of holding devices that were long enough to reach the tail rotor area and second the circumstance of flying with this device free of any cargo.

With respect to the first of these causes, it should be duly noted that the length of the holding cargo devices is normally determined by the physical characteristics of the area in which the work is to be performed.

Thus, for example, when performing an operation in which the aircraft is to deposit loads in a forested area, a sling long enough to allow the aircraft to remain above the trees is necessary.

As regards the accident in question, the conditions at both the pick-up area and the drop-off area did not seem to require a device as long as the one that was used.

In reference to the second of these noted factors, it should be pointed out that flights free of the triangular load mechanism could have been avoided, although to do so it would have been necessary for the helicopter to have been equipped with a hook capable of being opened from the cabin, located at the end of the short sling, and for it to have had access to a greater number of holding devices, as in this way the pilot could have left them on the mountain with each trip, next to the cargo, coming back to take them down at a later time.

3. CONCLUSION

3.1. Findings

In the first moments of the aircraft's descent manoeuvres, between the mountain and the bottom of the valley, the impact of the external cargo-holding system against the tail rotor occurred. As a result, the power transmission shaft to the anti-torque rotor was broken. This damage was due to two factors: the use of a holding system of excessive length; and the performance of the descent with the cargo device free of any load.

At that moment the helicopter found itself in flight conditions which did not manifest the loss of the tail rotor, as the slight torque was offset by the vertical stabilizers.

These flying conditions differed considerably from those the helicopter would have experienced in a normal flight.

It should be kept in mind that the emergency manoeuvres contained in the aircraft flight manual are intended for normal or near-normal flying conditions. Likewise, the continuing training and proficiency checks to which the pilots are subjected also routinely simulate normal or near-normal flying conditions. For that reason an evaluation should be made, by operators and pilots alike, of the actual flying conditions, including the topographical features under which such aerial helicopter flights with external cargo take place and reinforce the preparation and training on resolving emergencies under such special flying conditions.

In viewing this case, it seems that there was not a good previous assestment of the conditions under which the aircraft could reasonably have flown and consequently, it made difficult to face warrantly the response to a possible fault. A lack of knowledge of these circumstances could have prevented the pilot from adequately handling the emergency.

3.2. Causes

It is considered that the accident was probably caused by the two following factors:

- The use of an external cargo-holding device free of any load and of excessive length.
- The inadequate management of the emergency situation resulting from the breakage of the tail rotor transmission, which was possibly fostered by not having made a prior evaluation of the actual conditions in which the flight would take place, and by not having foreseen the counter-torque effect of the vertical stabilizers.

4. SAFETY RECOMMENDATIONS

REC 01/08. It is recommended that the operator of the aircraft, Heliswiss Iberia S.A., revise their Operations Manual so as to include specific operational procedures to perform special manoeuvres required during the aerial works that the company carries out and the expecting emergencies during the same.