DATA SUMMARY

LOCATION

Date and time	**Sunday, 4 August 2013; at 19:50 h**[1]
Site	**Puebla del Maestre (Badajoz, Spain)**

AIRCRAFT

Registration	**EC-KIE**
Type and model	**AIRBUS HELICOPTERS AS-350-B3**
Operator	**Inaer**

Engines

Type and model	**TURBOMECA ARRIEL 2B1**
Number	**1**

CREW

Pilot

Age	**28 years old**
Licence	**CPL(H)**
Total flight hours	**1,250 h**
Flight hours on the type	**100 h**

INJURIES

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

DAMAGE

Aircraft	**Significant**
Third parties	**None**

FLIGHT DATA

Operation	**Aerial work – Commercial – Firefighting**
Phase of flight	**Landing**

REPORT

Date of approval	**12 November 2014**

[1] All times in this report are local unless otherwise specified.

1. FACTUAL INFORMATION

1.1. History of the flight

On Sunday, 4 August 2013, an Airbus Helicopters[2] AS-350-B3 aircraft, registration EC-KIE, was involved in efforts to fight a forest fire between the towns of Pallares and Llerena (Badajoz).

After making several water drops, the pilot proceeded to the base at Calera de León (Badajoz) to refuel the aircraft and take the required rest.

During his break he was informed that the fire was under control, that no further water drops were necessary and that he could return to his usual base, which was located in Valencia de Alcántara (Cáceres). As a result, he proceeded to place the Bambi bucket in its basket and at the conclusion of his rest period, he took off and set course for the area of the fire to pick up the firefighting squad and return to base.

As he approached the fire area he received a call on the radio from the coordinator asking him to fly over a certain spot to see if the fire had reflashed. He proceeded to the indicated area and saw that the fire had indeed reflashed, as there were flames in the area. He reported this to the coordinator, who instructed him to drop water over the area.

He radioed the squad leader to inform him of his new orders and that he would land somewhere near their location so that they could deploy the Bambi bucket.

He saw a section of the old EX103 road and, believing it had the necessary characteristics to land, headed directly toward it.

He landed normally and verified that the helicopter was properly supported on the ground. Several minutes later the four members of the squad approached and two of them went inside the helicopter. The pilot informed them that they had to exit and deploy the Bambi bucket. Three of them proceeded to take the bucket out of its basket and laid it out in front of the helicopter.

After this two of them moved some distance away from the helicopter and a third stayed alongside the Bambi bucket to test its electrically operated opening system.

As the pilot stated, he saw the firefighter walk to the front of the helicopter and disappear underneath the nose, possibly to check something in the area where the Bambi bucket is latched to the helicopter.

[2] Airbus Helicopters is the current name of the aircraft manufacturer formerly called Eurocopter.

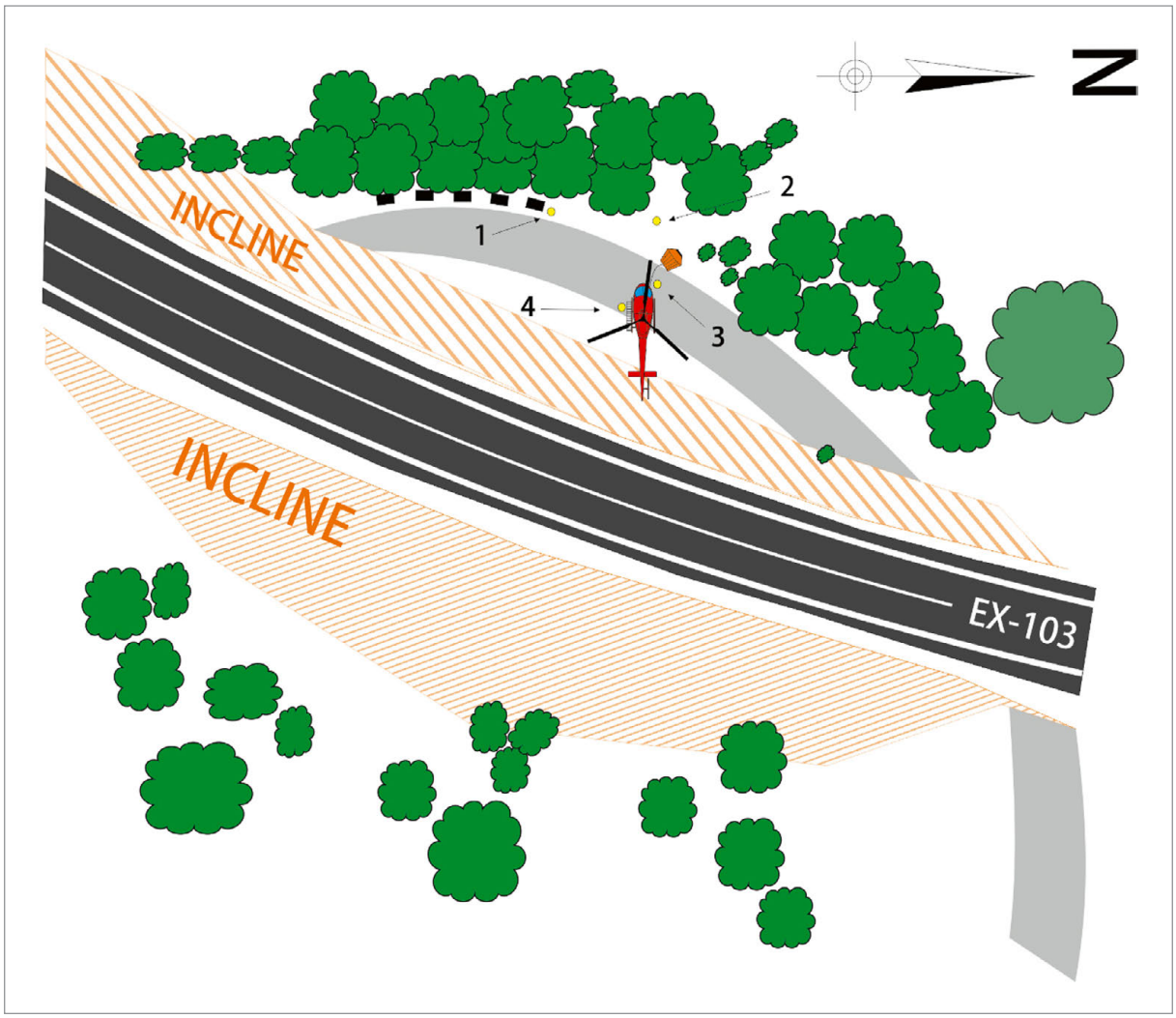


Figure 1. Sketch of the position of the helicopter and of the squad members at the start of the event

Just then the pilot felt the helicopter start to bounce with increasing intensity. Fearing for the firefighter underneath the helicopter, he decided to take off. He pulled on the collective and the helicopter started to climb, though the abrupt motions continued even more intensely.

The firefighter who was underneath the helicopter hooked himself to the right skid, remaining attached to it until he was able to take advantage of a forward motion of the helicopter to free himself.

The pilot tried to regain control of the aircraft but was unable to, losing all control of the helicopter, which ended up turned on its right side.

The pilot, who was uninjured, stopped the engine and cut the fuel and power. He was able to exit the helicopter, aided by the members of the squad.

1.2. Injuries to persons

The firefighter who was underneath the helicopter was slightly injured when he was cut, probably by several blade fragments that detached during the accident and impacted him.

1.3. Damage to aircraft

The aircraft suffered significant damage, which primarily affected the following areas:

- Landing gear
- Main rotor
- Anti-torque rotor
- Tail cone
- Horizontal stabilizer

1.4. Personnel information

Age:	28 years old
Nationality:	Spanish
License:	CPL(H), valid until 28/01/2018
Ratings:	• AS350/EC150/SP valid until 30/04/2014 • Forestry (firefighting only) valid until 30/09/2014 • Class 1 medical certificate valid until 13/07/2014
Total flight hours:	1,250 h
Flight hours on the aircraft type:	100 h

Regarding his experience in firefighting, the 2013 was his third campaign, having participated in the ones of the previous two years.

Activity

The pilot's duty schedule for the June and July preceding the accident is as shown in the timelines below, with duty days represented in amber and off-duty days shown in green.

JUNE 2013																											
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30

JULY 2013																												
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31

The pilot was on duty during the four days in August leading up to the day of the accident.

Flight hours

- In the previous 90 days: 30:34 h
- In the previous 30 days: 07:21 h
- In the previous 24 h: 03:00 h

On the day of the accident he had commenced his flight activity at 16:40.

Training

- 09/04/2013 Recurrent ground training and check on firefighting operations. ESP-OPS-H-TA-F-D02
- 30/04/2013 Training and check to renew the AS350 type rating.
- 31/05/2013 In-flight firefighting training. Form ESP-OPS-H-TA-F-D01

1.5. Aircraft information

1.5.1. *General information*

Manufacturer:	AIRBUS HELICOPTERS
Model:	AS-350-B3
Serial number:	4286
Year of construction:	2007
Airworthiness review certificate:	Valid until 12/07/2014
Engines, number/manufacturer and model:	One (1)/Turbomeca, Arriel-2B1, s/n: 23299
Empty weight:	1,275 kg
Maximum takeoff weight:	2,250 kg

Dimensions:
- Main rotor diameter: 10.69 m
- Total length: 12.94 m
- Fuselage length: 10.93 m
- Total height: 3.14 m

Aircraft hours: 1,355 h

Engine hours: 1,211 h

Landings: 4,066

Maintenance status:[3]

Inspection type	Date	Hours	Remarks
Basic (1,200 h/4 year)	30/05/2012	1,237	Engine replaced
100 h/annual	04/06/2013	1,311	Vibrations measured[2]
Monthly	04/07/2013	1,345	

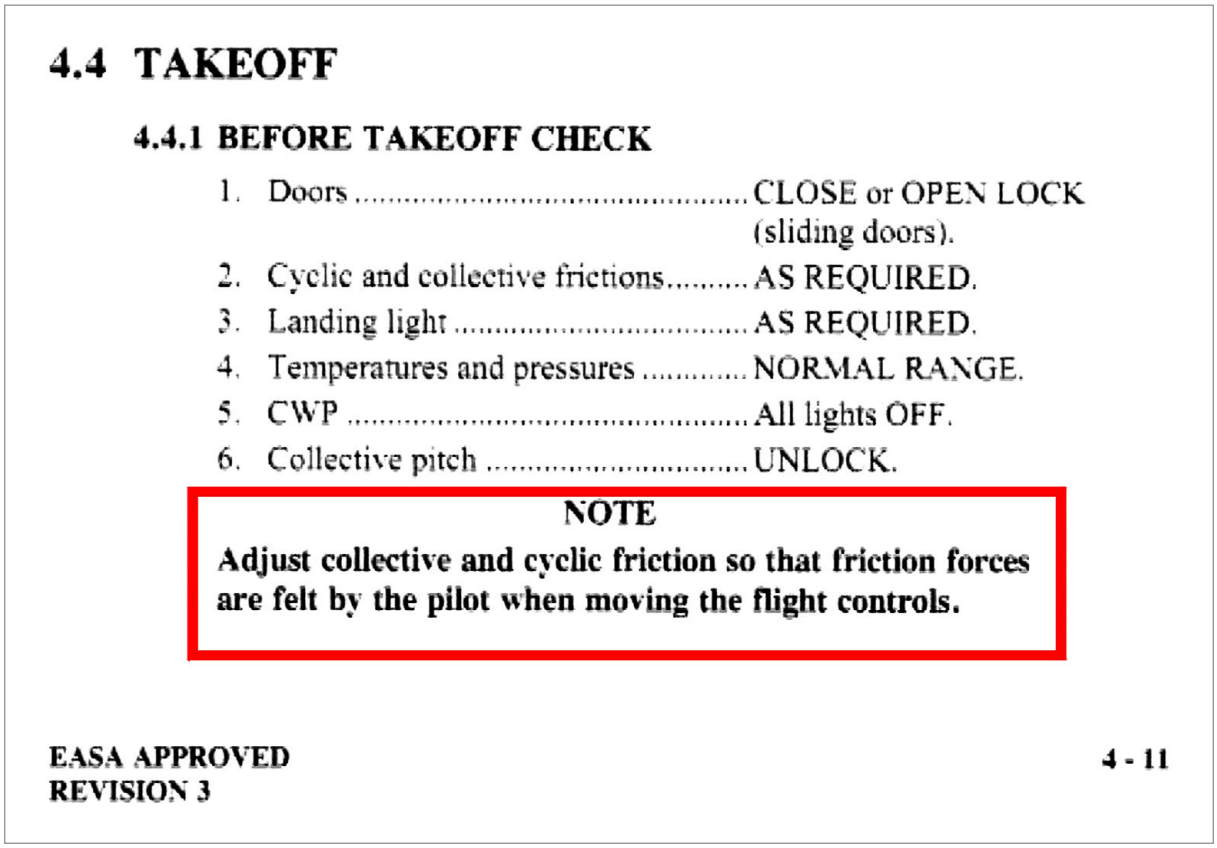
Modifications made to the aircraft after leaving the factory:

Approval ref.	Title
BI-002-06	Installation of Powerfill and Sacksafoam
CMA 165-BI	Installation of external loudspeaker
CMA 107-1	Installation of P2500 VHF-FM radio
CMA 163-BI	Installation of fleet tracking equipment
CMA 108-BI	Bamby bucket opening system
STC SR00213NY	Dart utility basket
SB 25.00.78	Installation of cable cutter
M12/053/24-BI	Portable GPS power supply

1.5.2. *Information on the flight manual*

In the Takeoff section (4.4), a note recommends adjusting the friction on the cyclic and collective controls so that the pilot feels resistance when moving the flight controls (see Figure 2).

[3] Vibrations were measured in the main rotor, tail rotor and tail rotor gearbox.



4.4 TAKEOFF

4.4.1 BEFORE TAKEOFF CHECK

1.	Doors	CLOSE or OPEN LOCK (sliding doors).
2.	Cyclic and collective frictions	AS REQUIRED.
3.	Landing light	AS REQUIRED.
4.	Temperatures and pressures	NORMAL RANGE.
5.	CWP	All lights OFF.
6.	Collective pitch	UNLOCK.

NOTE

Adjust collective and cyclic friction so that friction forces are felt by the pilot when moving the flight controls.

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4 - 11

Figure 2. Before takeoff checklist

Additionally, the engine pre-start checklist (4.3.1) in the Start-up section (4.3) includes the action to adjust the friction on the cyclic and collective controls (items 17 and 18).

1.6. Wreckage and impact information

1.6.1. *Information on the accident site*

The accident occurred on a section of the old EX-103 road.

As figures 3 and 4 show, this segment of the road is cut off at either end by a left turn in the new road, which is cut into the hillside to the east of the old road, which made a right turn at this location. On the west side of the old road is a wooded area containing mainly oak trees. The elevation of the new road is below that of the old one by about 4 m.

This segment of the old road basically comprises a platform with a distinctly curved and elevated geometry with respect to the new road.

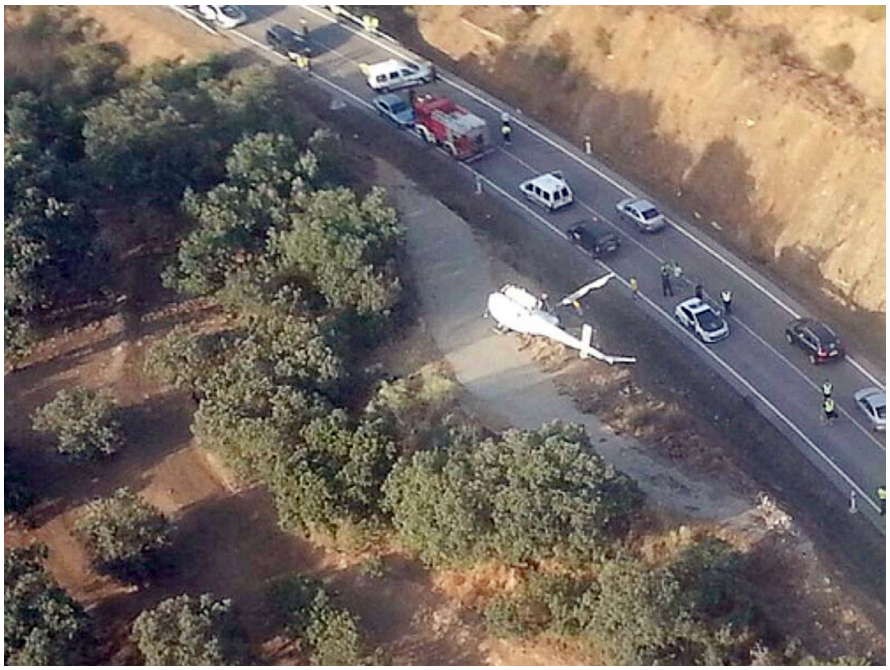

Figure 3. Aerial view of the accident site

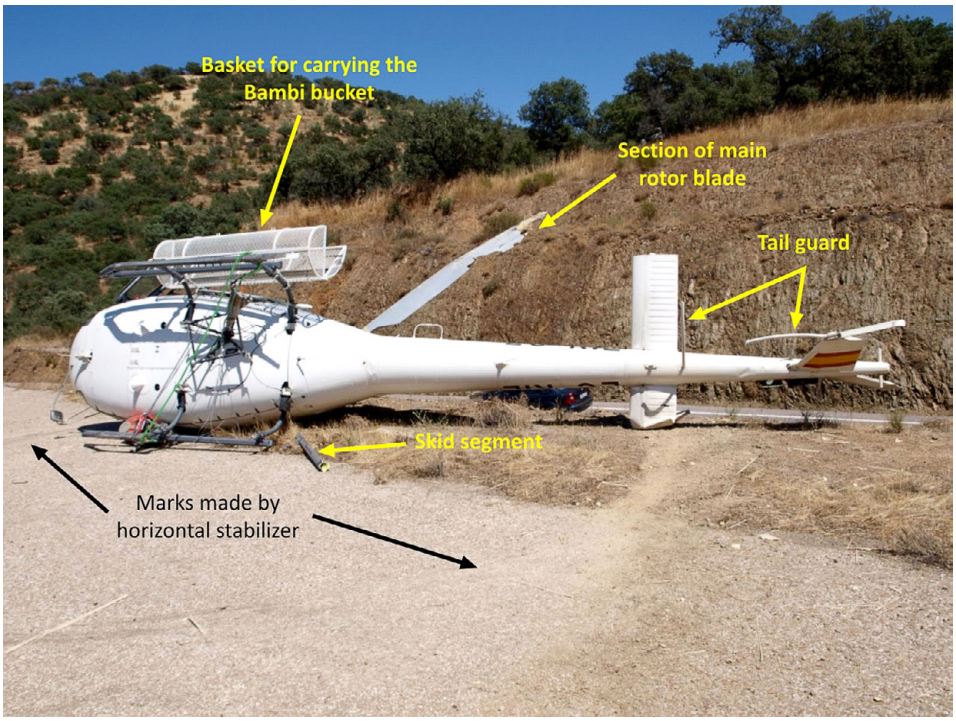

Figure 4. View of the aircraft wreckage

The part where the helicopter landed (central area of the segment) has a maximum width of about 10 m measured from the edge of the wooded area to the start of the incline. The pavement in this area is mixed, with dirt at either end and asphaltic concrete in the middle. The gradient in this area from west to east is rising-falling-rising.

1.6.2. *Wreckage information*

The aircraft was on its right side almost at the edge of the incline, with its longitudinal axis facing North (005°). The helicopter was resting on the right side of the cockpit, the main rotor and the right horizontal stabilizer.

There was a significant deformation on the stabilizer where it was supporting the weight of the helicopter.

The tail rotor had detached from the aircraft and was on the ditch of the new road, which runs along the bottom of the incline. One of the two blades on the anti-torque rotor had detached and was also at the bottom of the incline, but 20 m south of the rotor.

The main rotor still had some blade segments attached to it. Most of the blades had fractured due to the impact and the detached fragments were scattered to the east and west of the main wreckage.

Part of the right skid had detached due to two fractures, one on the skid itself, right behind the forward crossbar, and the other on the rear crossbar. The detached fragment was next to the main wreckage.

The aircraft's tail skid had a large number of perpendicular markings on it.

The tail guard, located at the rear of the tail boom and whose ends are attached to the fuselage and to the bottom of the vertical stabilizer, was broken in the middle. The part that remained attached to the fuselage was rotated 90° clockwise out of its normal position as seen from above.

There was a nearly circular mark that surrounded most of the aircraft and where the right horizontal stabilizer was found.

Surrounding the circular mark described in the preceding paragraph, especially to the south of the aircraft, was another, faint mark.

Next to it was yet a third faint, longitudinal mark facing west (heading 265°).

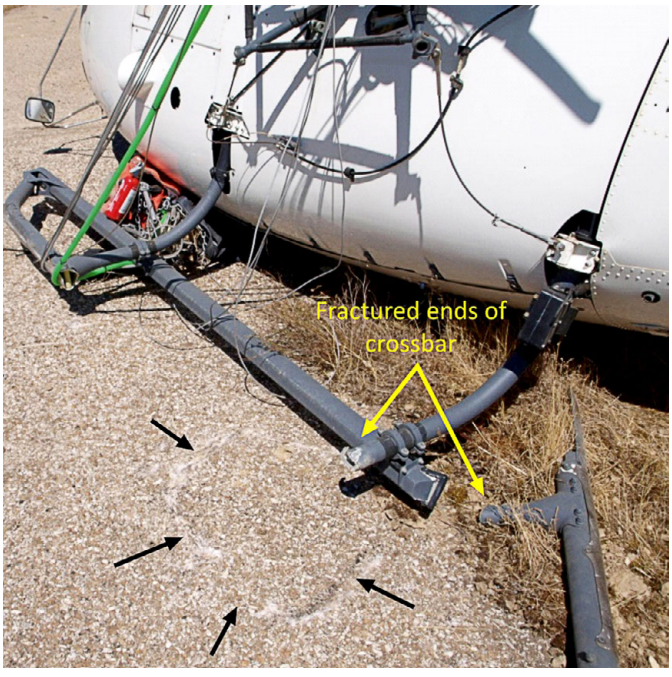

Figure 5. Close-up of the elliptical mark

There was an elliptical mark measuring about 60 × 40 cm near the area where the rear crossbar had fractured, the end of which exhibited significant impact damage.

In the area near the nose of the aircraft there were several deep, parallel marks that had been made by strong impacts.

There were no clear marks indicating where the tail rotor had impacted.

The mechanism used to adjust the friction of both the cyclic and collective controls was found to be in the position of minimum friction. The collective pitch control was not locked in its lower position.

1.6.3. *Inspection of the aircraft*

The aircraft was taken to the operator's facilities for the purpose of subjecting it to a more detailed inspection. Aiding in this task was the Bureau d'Enquêtes et d'Analyses pour la Sécurité de l'Aviation Civile (BEA), which is the French authority charged with investigating civil aviation accidents and incidents, and the aircraft manufacturer, Airbus Helicopters.

1.6.3.1. Card AMM 05-50-00, 6-20

In light of the information reported by the pilot regarding the behavior of the aircraft, it was decided to inspect it as per the instructions on "card AMM 05-50-00, 6-20. Actions to be taken in the event of abnormal behavior of helicopter on the ground, with rotor spinning", which describes the parts of the helicopter to be inspected if it behaves abnormally while on the ground with the rotors turning. These parts include:

- Main rotor
- Gearbox
- Landing gear
- Starflex
- Tail rotor

Due to the damage suffered by the helicopter during the accident, it was not possible to do all of the actions indicated on the card, especially those involving the rotors. A summary of the findings is provided below.

Main rotor head

- Starflex. Overall it was heavily damaged due to the impact of the blades against the ground, which caused the arm on the red blade to fracture. The damage found was consistent with the impact of the blades against the ground at power. No evidence of previous damage was found.

- Ball joint. Due to the impacts of the blades against the ground, the ball joint could not be checked. A visual inspection, however, did not reveal any abnormalities or signs of existing damage.
- Spherical thrust bearings. These had come loose from the starflex due to the impacts. The elastomers did not exhibit cracks, detachments or protrusions.
- Frequency adapters. They were severely damaged by the impacts, though no evidence of an existing fault was found.

Main gearbox suspension

- Laminated stops. These were still properly positioned and did not exhibit any shifting, bending, separations or damage.
- Gearbox suspension bars. These were still properly positioned and did not exhibit any shifting, bending, separations or damage.

Landing gear

- Landing gear. Due to the impact it was partially fractured and bent. As a result, it was not possible to do the specified checks. The different parts comprising the gear, however, with the exception of the broken and detached skid segment, were properly connected and showed no signs of cracking or corrosion. There was also no evidence of damage from before the accident.
- Landing gear attachments. The gear was properly connected to the helicopter structure and to the dampers and showed no signs of warping, cracking or corrosion.
- Blades at the rear of the skids. Their function is to reduce the risk of resonance on the ground while landing, though they have no effect once the aircraft is resting on the ground. The inspection consists of measuring the distance from the end of the strip and the extension of the top part of the skid, which must not exceed 85 mm.

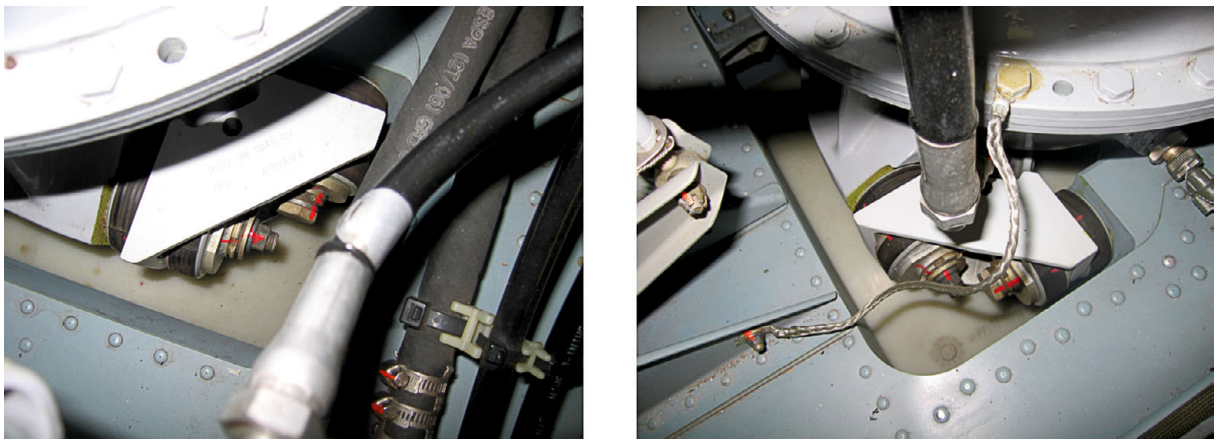

Figure 6. Left rear (left) and right front (right) attachments

Although these checks were not valid in this case due to the deformations caused during the accident, they were carried out for information purposes, yielding the following results:

— Left skid: 89 mm
— Right skid: 73 mm

- Dampers. They were properly attached to the landing gear and exhibited no abnormalities.
  They were detached for an operational test, which consists of measuring how long it takes the damper to stretch a given length under a load of 20 daN, this time being limited to between 7.1 and 12.5 s. This test was repeated several times, yielding the following results:

  — Left damper: 9.7-9.4 s
  — Right damper: 9.8 s – 9.6 s – 9.7 s

Anti-torque rotor

The blades were severely damaged from the impact with the ground, which impeded carrying out the required inspections. No evidence was found, however, of any pre-existing damage.

Anti-torque gearbox

As with the blades, the gearbox was severely damaged, which made it impossible to carry out the required inspections, though no evidence was found of any pre-existing damage either.

1.6.3.2. Cyclic and collective pitch controls

As stated in 1.6.2, the friction on the cyclic and collective controls was set to the minimum on both.

The device that is used to lock the collective pitch control at its lowest position was verified to be working properly.

The throttle grip was found in the "flight" position.

1.6.3.3. VEMD[4] and DECU[5]

These two units store information on certain engine and rotor parameters, and any over limits of these parameters that could be of use to an investigation.

[4] Vehicle Engine Monitoring Display.
[5] Digital Engine Control Unit.

In order to download their data, they were removed and sent to the Bureau d'Enquêtes et d'Analyses pour la Sécurité de l'Aviation Civile (BEA), where they first underwent an inspection in an effort to determine whether their condition allowed a direct reading of the data stored on them.

After this inspection, it was concluded that a direct reading was feasible, so both units were sent to their respective manufacturers, the VEMD to Airbus Helicopters and the DECU to Turbomeca.

VEMD

The unit was energized on the test bench in accordance with BEA/Airbus Helicopters procedures. All of the data recorded on the unit were displayed directly on its screen and photographed.

The data for the last flight recorded were associated with flight 1878, which lasted 16 minutes[6]. This flight recorded one fault and one over limit.

The fault involved a discrepancy in the position of the anticipator potentiometer on the collective. The relevant parameters recorded for this fault are as follows:

Time	Description	NG[6] (%)	Torque (%)	T4[7] (°C)	NF[8] (rpm)
15:17 min	COLL PITCH POT L	97.5	127.3	773	271

During this flight the engine torque was over limited several times, the maximum value being 128%. The duration of these violations were as follows:

1 s between 105% and 110%.
3 s between 110% and 118%
1 s between 118% and 128%

DECU

The information contained on this unit was downloaded at the Turbomeca test bench.

Fault block number 1 was the most recent and was associated with start-up number 8576. This fault block had been recorded 968 s (16:08 min) after the DECU was energized and contained the following messages:

[6] The VEMD starts calculating the flight time when the speed of the free turbine exceeds 60%.
[7] Measured rotation speed of the gas generator.
[8] Average temperature at the exit of the gas generator turbine.
[9] Rotation speed of the free turbine calculated in rotor speed.

- ADC channel B / OSS; DECU
  This message informs of a discrepancy in the analog to digital converter on channel B.
- Stepper motor / OSS; DECU
  This message concerns the fuel flow actuator.
- Collective pitch measurement / AS; DECU
  This message indicates that the value of the anticipator potentiometer on the collective is out-of-specification. This may be due to a defect, an excess or a transient.

1.7. Eyewitness interviews

1.7.1. *Pilot's statement*

He began by stating that on the day of the event he was at his home base in Valencia de Alcántara (Cáceres). At 16:25 he was notified of the presence of a fire in La Puebla del Maestre (Badajoz).

About 10 to 12 minutes later he took off from the base, carrying onboard the four-person firefighting squad.

They reached the fire site and he set the helicopter down after finding a place to land. After the firefighters deployed the Bambi bucket, he took off. The squad remained behind to fight the fire from the ground.

The firefighting coordinator instructed him where to make the water drops.

After some time, he went to the base in the town of Calera de León, where he planned to refuel the aircraft and take his legally required break every two duty hours.

While he was there another helicopter arrived. Shortly thereafter he was notified that the fire was under control and that no more water drops were needed, meaning he could return to his home base.

As a result, they picked up the Bambi buckets on both helicopters and placed them in their respective baskets.

Once his rest time was complete, he took off en route to the area of the fire to pick up the squad and return to Valencia de Alcántara.

While in the vicinity of the fire he received a call from the coordinator informing him that the fire appeared to have reflashed and asking him to fly over a specific area to confirm this report.

He went to the specified area and confirmed that the fire had not only reflashed, but that there were flames. He reported this information to the coordinator, who instructed him to make water drops over the area to extinguish the fire.

He radioed the squad leader to convey the new information and to inform him that he would be landing somewhere near their location so they could deploy the Bambi bucket.

He flew over the area where the squad was, which was a scrubland covered mainly in oak trees. The area offered few spaces suitable for landing.

He saw a segment of an old road that he determined to be sufficiently well suited to conduct a safe landing.

He approached it flying from the south-southwest over the new road and as he neared the site where he had chosen to land, he turned right to hover over the site.

He landed with the aircraft practically facing west, as the wind was coming from that direction.

He calculated that in that landing position, the aircraft protruded outside the platform that the old road passed through. On the other side, despite the small dimensions, he had sufficient separation from obstacles, which was primarily the oak trees.

He waited there on the ground for a few minutes until the squad arrived.

They opened the helicopter door and two firefighters climbed onboard. He radioed the leader to remind them that they were not returning to base yet. He then turned around to inform the two firefighters who had climbed onboard that they had to get out.

They did and then they proceeded to take the Bambi bucket out of its carrying basket (this operation requires three people). They then laid it out in front of and slightly to the right of the helicopter.

After this, two of them went to one side and the third remained next to the Bambi bucket to test its electrical opening system. The pilot stated that this test is performed every time the bucket is removed from its basket.

At one point he saw a firefighter walking to the front of the helicopter and then bend down to go under the aircraft.

He had the collective control in its lowest position and the throttle grip in the flight position.

Almost instantly he felt the helicopter start to bounce. The description he gave of the bounces was that the skids did not rise up simultaneously, but rather alternating, that is, the helicopter fell first on one skid, bounced up, and fell on the other, and so on.

Fearing for the firefighter underneath the helicopter, he pulled on the collective. He could not specify whether this action was fast or not, or how he commanded the pedals, though he said that applying the pedal while pulling on the collective is almost

instinctive to him. He could not state how much input he provided to the pedal, but he ensured having done it.

He thought that the helicopter had started to climb, though this did not diminish the bouncing action; on the contrary, the bouncing was becoming more pronounced.

He tried to control the aircraft but was unable to, eventually becoming completely uncontrollable.

He could not specify how the helicopter might have moved or turned afterwards before it ended up turned over on its right side.

He cut the fuel, stopped the engine and turned off the power.

The firefighters responded quickly and told him that smoke was coming out of the engine. He punched out one of the cockpit windows and gave them the extinguisher in the cockpit so they could discharge it on the turbine.

Once the extinguisher was discharged, they opened the helicopter door and helped him exit. Once outside he was relieved to see all four members of the squad.

Shortly afterwards they noticed that one of the firefighters had blood stains on his back that had been caused by lacerations. So they laid him face down and notified emergency services.

When the firefighters arrived the squad asked them for a CO_2 extinguisher, which they discharged on the turbine.

1.7.2. *Squad members*

No. 1

He was the newest member of the squad, having become a squad member only two months earlier.

By the time they reached the accident site, the helicopter was already there. Since they thought they had completed their mission and were returning to their home base, they proceeded to stow their tools in the Bambi bucket basket. They then opened the helicopter door and two of them climbed onboard. The pilot turned to them and told them to exit because he had to make more water drops.

They got out and three of them took out the Bambi bucket and laid it out in front and slightly to the right of the helicopter.

He then proceeded to take out some tools and take them to the left of the helicopter, specifically, to an area with factory-made guard rails for the old segment of road.

The squad leader was in front of the helicopter so he could signal the pilot.

Another firefighter was next to the Bambi bucket in order to test its opening system, and the third was closing the basket for the bucket.

After leaving the tools, he turned toward the helicopter and saw it was climbing. He estimated it climbed about two meters and then it moved forward and backward. He then thought it turned slightly to its left, since he could see the pilot's face. And that is when the tail rotor impacted the ground, though he could not pinpoint the exact location of the impact.

The helicopter started rotating about itself very quickly. He thought it made a complete revolution and then the main rotor blades impacted.

He saw one of his colleagues trying to avoid the helicopter, at one point noticing how he grabbed the right skid before letting go.

As for the test of the Bambi bucket, he stated that some pilots do not like to and do not do it, while others do carry it out.

He was also asked to watch a video of a helicopter of the same model experiencing ground resonance to see if the behavior of the helicopter in the video matched that of the accident helicopter.

This squad member indicated that the two behaviors were completely different.

No. 2

He began by saying that the helicopter had come from refueling in a nearby base, and that the fire coordinator had told them that the fire was under control and they could return to their base.

They spoke to the pilot, who said that he would land in the same place as when they had come from the base, but in the end the pilot decided to land elsewhere.

The site they had used upon their arrival had been a level patch between the oak trees that was a bit further away from them than the accident site, though the difference was not significant. As concerns the features of the two sites, he indicated that the former was better as it was much wider.

They arrived at the spot where the helicopter had landed and saw that it was fairly small.

At first there was some confusion, since they thought they were returning to base. That is why they put away the tools and two of the workers climbed onboard. That is when the pilot radioed him to inform them that they were not going back and that he had to make more drops since the fire had reflashed. He saw the pilot turn around toward the two firefighters who had climbed onboard, after which they got out.

He was standing in front of the cockpit and instructed the squad to remove the Bambi bucket from its basket. Once deployed, one of the workers stayed alongside the bucket to do the operational test of its electrical opening system.

The helicopter rose suddenly. He guessed it must have risen some 25 cm. Then it moved forward and back while bouncing. He stated it also rotated 180° to the right (the nose of the helicopter turned to the left of the eyewitness who was standing in front of him).

As regards the place where the tail rotor impacted, he could not specify the location as he was on lying down on the ground and had not seen it.

Concerning the test of the opening system, he stated that there are B3 pilots (same model as the accident helicopter) who prefer not to do it and only check it on the first water drop. On the Bell 407, however, they always check it since when the bucket is stowed in the baggage compartment, it is disconnected from the load hook and the electrical system, and it all has to be reconnected when it is deployed again.

No. 3

They arrived at the place where the helicopter had landed. Since their orders were to return to base, they proceeded to stow their tools in the basket for the Bambi bucket, which was already stowed.

The squad leader then told them they had to take out the bucket from its basket, which they did before laying it out in front of and to the right of the helicopter.

He kneeled down next to the bucket to test its electrical opening system. This test requires the pilot to press the opening button while the firefighter pulls on the cable. If the system works properly, when the pilot presses the button the cable should release, and when pulling manually on the cable it should unspool a certain length. He then releases it and the cable should reel in to the same position as at the start of the test.

He stated that to do the test correctly, he has to kneel down alongside the helicopter.

On the day of the accident he was already in that position awaiting the squad leader's signal to pull on the cable. He then heard a noise he thought was the skid scraping against the ground. Suddenly the helicopter bounced forward, that is, toward him.

He threw himself down and rolled around on the ground trying to avoid the helicopter and flee the area.

The helicopter climbed a little, but it was as though it could not take off. This kept him from getting away. At one point the helicopter rose a little more and he threw himself at the right skid, which he managed to grab.

He held on to the skid for a few seconds though his feet remained on the ground at all times, since the helicopter did not climb much. He took advantage of a forward motion of the helicopter to let go of the skid and propel himself to the right. He remained on the ground and heard banging noises, though he did not know where or what their source was, as he remained on the ground and could not see.

He stood up to run away and felt something hit him on the leg and a burning sensation on his back.

He managed to make it down to the wooded area to the right of helicopter (looking forward), and when the helicopter stopped, he climbed once more to the flat area. On reaching it, he saw that his colleagues were helping the pilot exit the helicopter.

This person was asked to watch the same video as squad member no. 1.

He was of the same opinion as his colleague and agreed that the two behaviors were nothing alike.

No. 4

He began by stating that the pilot alone had selected the place where the helicopter landed, and that it was different from the place they had used to land when they arrived from the base in Valencia de Alcántara.

They arrived at the site and started stowing their tools since they had instructions to return to base. The squad leader then told them they had to take out the basket since the coordinator had ordered more drops.

Between another firefighter and him they took out the bucket and laid it out in front of and to the right of the helicopter.

In the meantime another crewmember took out the tools. Once the bucket was laid out, one of the firefighters remained alongside it to do the test.

He went to the left side of the helicopter to close the basket used to transport the bucket. As he did this, he saw the helicopter rise (about 20 or 30 cm), and that the left skid was brushing up against his legs. The helicopter suddenly bounced to the rear.

He shouted to his colleagues to "get out" and "get down" and ran into the woods in front of the helicopter, where he dropped to the ground and rolled to the edge of the wooded area.

He saw the squad leader take cover behind the guard rails.

Once the helicopter stopped, he walked toward it. Upon reaching it he noticed that it was leaking a small amount of fuel and that there was smoke coming out of the cockpit. He saw that the pilot was conscious and asked him for the extinguisher to discharge it on the turbine.

When asked about the position of the skids before the helicopter started to bounce, he stated that the left one was partly on the paved area and partly on the dirt.

As for the test of the opening system, he stated that not all pilots do it.

1.8. Flight recorders

The aircraft was not equipped with a flight data recorder (FDR) or a cockpit voice recorder (CVR), neither one being required for this aircraft type.

1.9. Organizational and management information

1.9.1. *Test of the bucket's opening system*

Chapter 3 of the Special Operations Manual on firefighting (MOE) contains the instructions of an operational nature to be used by flight crews during firefighting operations.

Item 3.8.1 in this manual, called "Operating with the Bambi bucket", states the following:

> On reaching the drop site, the personnel will disembark and take out the Bambi bucket, lay it out on the right side of the helicopter, ensuring that the cables are a safe distance away from the landing gear in helicopters with wheeled gear, or underneath the skid in helicopters with skis, to keep it from tangling up in the gear. The bucket is to be in a horizontal position with the fill nozzle facing the helicopter. Once the bucket is laid out, one of the FFS members who operate the bucket will give a signal to start the water drop test, and another member will check the opening mechanism by pulling manually on the release cable and then ensuring it returns to its initial position.

> Following this test they will signal that everything is OK and join up with the remaining members of the FFS. This entire operation, as well as the stowing of the bucket and inserting it into the cabin at the end of the operation, will be supervised at all times by the second crewmember, if there is one, or by the FFS leader if not.

Additionally, item 3.7.4.1 in this same manual, titled "Preliminary check of the performance and the electrical release system", provides the following instructions:

> The performance of the h/c and the operation of the electrical water drop system must be checked when water is first taken on. This will be done by taking on as little water as possible and checking engine parameters, temperatures and pressures while hovering, ensuring they are all within limits. Ensure also that no warning/alarm lights are on and that enough reserve power is available to take off. At the conclusion of this check, the electrical button to discharge the water will be pressed to ensure that the electrical discharge system works properly. This is important since if the water cannot be dropped on the fire during a dropping run due to a faulty electrical connection, an undesirable situation will result from being unable to release the load, in addition to having a high fuel weight onboard and possibly being in a hostile mountain environment.

1.9.2. *Landing point*

In the Special Operations Manual, Firefighting (MOE-LCI), point 2.2.1 states the following regarding the landing point:

> Landing spot
>
> The landing spot for a FF flight must be sufficiently wide and properly free from obstacles. For reference purposes, an area that is twice the diameter of the rotor can be considered to be sufficiently wide.
>
> As for the factors to be used to select the landing spot from the air, it provides the following instructions:
>
> The landing spot for dropping off or picking up firefighters must be carefully studied. To this end the PIC (Pilot in command) must keep in mind:
>
> Selecting the landing spot
>
> - Fly around the chosen spot:
>
> — A high reconnaissance run, above 300 ft, to evaluate the area surrounding the spot,

— A low reconnaissance run, above 100 ft, to check for obstacles on the selected approach and departure paths, and
— A final reconnaissance run while on slow approach, >60 kts, to check the ground.

- wind direction and speed
- elevation of the landing spot
- nearby obstacles
- approach and departure paths
- helicopter weight and reserve power
- condition and gradient of terrain
- proximity of operational area and ease of access for firefighters.

Factors that determine the landing spot selected from the ground

If the members of the FF squad are on the ground and are requesting to be picked up by the h/c, the following points are to be considered when selecting the landing spot to be picked up:

During the landing

Stand in view of the pilot, in front of the helicopter and leaving the landing spot clear.
Be particularly careful with the rotors, especially the tail rotor which, given its speed, may not be visible.
Do not approach the helicopter without being instructed to do so by the crew and do not give any unnecessary signals.

1.10. Additional information

1.10.1. *Training the aircraft operator is required to give squad members*

The aircraft operator has a workplace health and safety management system in place, as part of which it has conducted a study to evaluate the occupational hazards inherent to helicopter operations. This study includes the work done by third parties with the operator's aerial assets.

As for the personnel who comprise the usual crew of a helicopter (e.g. air-dropped firefighting squads, medical personnel, rescue personnel, etc.), this document states that they will be informed of the helicopter's safety and emergency systems in general, and of the use and operation of those systems on the specific model of helicopter in which they will be flying. This information and training will include:

- Identification of every helicopter access door, both in the cockpit and in the passenger/cargo compartments.
- Normal opening and closing operations of every helicopter access door, both in the cockpit and in the passenger/cargo compartments.
- Identification, location and operation of the portable fire extinguishers inside the helicopter.
- Identification, location and operation of every emergency exit in the helicopter, including emergency releases on doors or windows.
- Identification and use of the various restraint systems (seat belts) in the helicopter.
- Location and activation of the emergency beacon (ELT), if applicable.
- Location and activation of the emergency fuel cut-off systems, if applicable.
- Location and activation of the emergency electrical shut-down systems, if applicable.

As for "Safety when deploying and/or stowing the BAMBI BUCKET", it provides the following instructions:

Every helicopter model has or uses different carrying systems and procedures for maneuvers with the Bambi bucket. As a result, air-dropped firefighting crews must be instructed and trained on the model being used at any given time.

If a different helicopter model is used for any reason, the members of the air-dropped firefighting crews must be trained on the new model and in its associated procedures.

The maneuvers involving the removal, deployment, retraction, folding and stowing of the Bambi bucket in its carrying basket are to be carried out by members of the air-dropped firefighting squad.

These personnel shall be designated as the permanent and usual handlers of the Bambi bucket. Only in their absence, medical leave or any other unforeseen circumstance can another designated crewmember handle this task.

Even though the same designated personnel will handle the Bambi bucket during an operation, EVERY member of the air-dropped firefighting brigade shall be instructed and trained on the maneuvers and procedures associated with it, such as:

- Stowing and deploying it
- Loading and unloading
- Securing
- Latching and unlatching the load hook (if applicable)
- Electrical connection (if applicable)
- Procedure for checking the water release system
- Identifying and solving typical malfunctions or problems.

They must also receive training on the various components and elements of the Bambi bucket and be able to determine its condition and ensure its safe and proper operation.

Periodic hands-on training will also be held at the pilot's discretion, or weekly at a minimum if there are no flights or services where this training was conducted. The leader of each squad must keep a record for each crewmember assigned to handle the Bambi bucket of all the training carried out by each one and the date of the training.

During operations, all maneuvers are to be supervised by the leader or foreman of the air-dropped firefighters, who will relay all maneuvers to the pilot flying either visually or via radio.

1.10.2. *Training received by firefighting squad*

On 31 May and 12 June, the accident pilot gave initial and refresher training at the base in Valencia de Alcántara on safety and emergencies to the various members of the firefighting squads, including the four members who comprised the squad assigned to the helicopter on the day of the accident. This training covered:

- General safety regulations on the ground.
- General safety regulations in the air.
- Safety regulations for personnel transported by helicopter:

  — Helicopter safety and emergency systems.
  — Safety while boarding.
  — In-flight safety.
  — Safety while disembarking.
  — Safety during takeoff and/or stowing the Bambi bucket.

- Steps to take in an emergency:

  — Emergency descent.
  — Brace position.
  — Exiting the helicopter.
  — Smoke in the cabin.
  — Fire in the cabin.
  — Fire or explosion after impact.

- Flight practice.
- Other actions: water impact, steps to take.

They also attended to the following formation sessions and training with helicopters Bell 407 and Airbus Helicopters AS-350-B3:

- 21 May with squad "Aire A", Bell 407 and pilot different from the accident one.
- 21 May with squad "Aire B", Bell 407 and pilot different from the accident one.
- 4 June with squad "Aire A", Eurocopter AS-350-B3.
- 5 June with squad "Aire B", Eurocopter AS-350-B3.
- 5 June with squad "Aire A", Eurocopter AS-350-B3.
- 6 June with squad "Aire B", Eurocopter AS-350-B3.
- 11 June con squad "Aire B", Eurocopter AS-350-B3
- 22 July with squad "Aire A", Eurocopter AS-350-B3 and pilot different from the accident one.
- 22 July with squad "Aire B", Eurocopter AS-350-B3 and pilot different from the accident one.

In addition, all crewmembers had received specific training on extinguishing fires and on preventing associated occupational hazards.

1.10.3. *Evaluation of the Bambi bucket opening test*

The investigation into the accident revealed a certain difference of opinion among pilots regarding the need to do the opening test on the Bambi bucket when it is taken out of its basket, to the point where some pilots did not carry out this test.

In light of this the investigation team decided it would be interesting to ascertain the opinion of pilots as a whole on this issue, to which end it recommended to the operator that it survey its pilots in an effort to gather their opinions regarding the test of the opening system for the bucket.

Inaer picked a group of highly experienced firefighting instructors and pilots and asked for their opinion on the subject.

It should be noted that there are several different cases depending on the helicopter model in question, though they can be grouped into the following two main groups:

- Bambi bucket transported in an external basket and always connected, both to the load hook and the electrical control system.
- Bambi bucket transported in the helicopter's luggage compartment and physically disconnected.

The procedures used by the operator at the time of the accident, which involve checking the operation of the opening system, were the same for every helicopter type and required three checks:

- Pre-flight test. Done by the pilot and a mechanic before the flight.
- Test by the squad. Done by the pilot and the squad every time the bucket is deployed. This was the test being done when the accident took place.
- Over-water test. Done by the pilot before starting the water drops.

The replies received were fairly consistent. The analysis of the current situation and its pros and cons was based on the risk/reward ratio, with the pre-flight and over-water tests being regarded as unquestionably beneficial in every scenario.

The test by the squad, however, was mostly viewed as dangerous, since it required having a squad member very close to the helicopter, which increased the risk of an accident.

As for the pros, there were rather few in the cases of the bucket type that does not have to be disconnected in order to be stowed, since its connections would not have been manipulated after the last pre-flight check, which makes it improbable that they would have been altered in the meantime. The test itself also has few benefits since the possibility remains that a disconnection may occur on takeoff that will disable the opening mechanism, an occurrence that would be detected by the pilot during the water test.

In contrast, the general opinion was that buckets that are disconnected when they are stowed should be tested, since their connections are altered and need to be checked before being used.

In light of this, the operator decided to change its procedures and do away with the bucket opening test done by squads for buckets whose connections are not affected by the stowing/unstowing process.

This information has already been conveyed to all instructors so they can start passing it on to the crews. There are also plans to inform crews of this during the workshops that are held before the start of the firefighting season.

The operator is also preparing five operating procedures, one for each aircraft model, containing instructions for operating with the Bambi bucket. These are expected to be distributed before the start of the summer campaign and will include the instructions for testing the bucket.

2. ANALYSIS

2.1. Communications

While the communications between the pilot and fire coordinator were effective, those between the pilot and the squad leader did not appear to be, since two squad members boarded the helicopter believing they were returning to base.

2.2. Landing spot

According to his statement, the pilot did not do the high and low reconnaissance runs, instead flying over the road before landing directly. He was cognizant of the landing area's limited size.

The dimensions of the area where he landed are well below the two-rotor diameter limit regarded as the minimum in the MOE. In fact, when the helicopter landed, the aft part of the tail cone was hanging over the incline that separated the two roads.

Due to the limited area, the squad members were not able to stand in front of the helicopter, having to do so to the left of the helicopter instead, next to some road signs.

2.3. Actions of the squad

Since the area where the squad had been operating was south of the place where the helicopter had landed, its members had to gain access to the landing spot from the left of the helicopter, which is on the opposite side of where the pilot sits in the helicopter.

The squad leader placed himself in front of the helicopter and once received the clearance from the pilot to come closer to the helicopter, he transmitted this information to the rest of the squad. Possibly due a problem in the last communication held between the pilot and the squad leader, the latter did not understand that the squad had to continue with the fire extinguishing operations and thought that they were going to return to the base. As a consequence the members of the squad approached the helicopter and proceeded to pack the tools and get onboard instead of extracting the bambi bucket as the pilot was expecting.

When the statements from the other members of the squad were reviewed, a certain disagreement was observed in two of them regarding the number of people involved in unstowing the Bambi bucket. Squad member no. 1 said that three people (including himself) did it, while no. 4 said that this task was accomplished by him and another colleague.

As for no. 3, though he did not specify a number, he did state that he took part in unstowing the bucket.

The minimum number of firefighters required to unstow a bucket depends on the weight of the equipment, though normally it is between two and three.

In the three statements there is one piece of information that can shed light on this issue: each individual states that he took part in the activity.

Since information regarding one's own involvement is more reliable than information given about someone else, it may be concluded that, in all likelihood, three members of the squad were involved in unstowing and laying out the Bambi bucket.

2.4. Test of the opening system on the Bambi bucket

Due to the uncertainty regarding the risk/reward ratio involved in carrying out the test of the opening system on the bucket, the operator surveyed some of its personnel.

This survey revealed that in helicopters where the bucket opening system is not disconnected, it is not necessary to carry out this test every time it is unfolded.

The operator is disseminating this information to its crews through the workshops that are held before the firefighting season starts. It is also preparing written procedures for the different models it uses that it plans to have distributed to its crews before the summer campaign.

This Commission believes that omitting the test of the opening system on the bucket in those models where the folding/unfolding task does not require changing any of its connections will make firefighting operations safer by minimizing the exposure of the squad members.

In a positive light, the operator's response to this issue is also worth noting. It conducted a survey of a significant sample, both in qualitative and quantitative terms, of its crews and drew conclusions that have resulted in changes to its procedures, changes that have been implemented without delay.

2.5. Analysis of the initial loss of control of the aircraft

The accident sequence began when the aircraft started to move uncontrollably.

Ground resonance or oscillation is a phenomenon that occurs when the main rotor first drag vibration mode approaches the natural roll frequency of the aircraft.

The following figure provides a basic diagram of the ground resonance phenomenon, which shows the margin that exists between the curves in normal conditions. When the margin drops to zero, the two curves cross and resonance can appear.

There are several factors that can affect this diagram, and thus alter the position of the curves: a change in the speed of the main rotor (increase), a variation in the main rotor head's stiffness characteristics, a change in the aircraft's natural vibration frequency, etc.

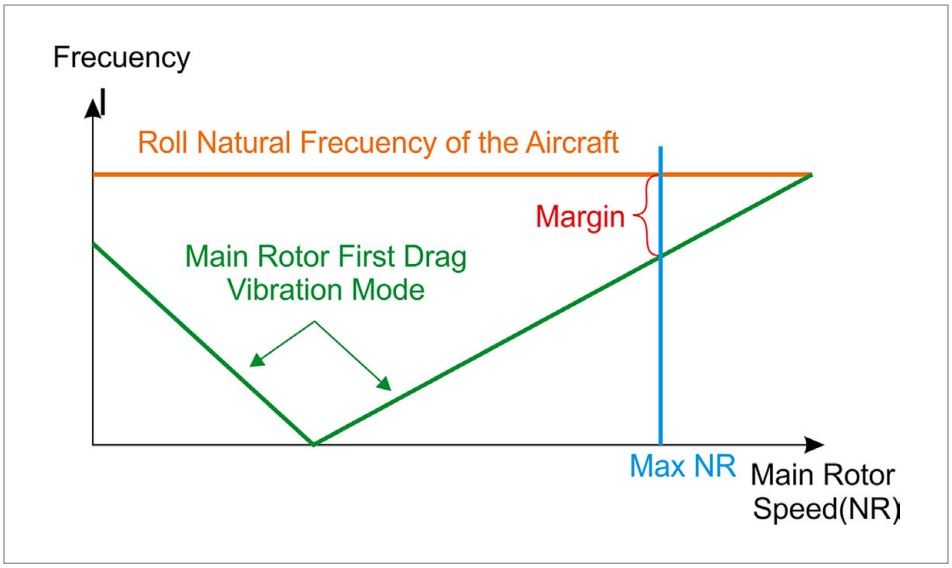

Figure 7. Basic ground resonance graph

Increasing the speed of the main rotor, which would shift the blue line in the graph to the right, can result from an input made by the pilot to the fuel control (not possible on the model in this accident) or from a problem with the governor, for example.

The stiffness of the rotor head can be modified by changes to the characteristics of the frequency dampers, for example, and would result in an upward shift of the green line.

The aircraft's natural vibration frequency can be affected by any of the following factors:

- Aircraft weight
- Status of the landing gear
- Status of the landing gear dampers
- Characteristics of the ground

The following graph shows the effect of changing (lowering) the aircraft's natural vibration frequency. The red circle marks the point at which the two lines intersect and the resonance can begin.

The information recorded on the DECU and VEMD indicates that there was no significant change to the rotation speed of the main rotor.

The potentiometer on the collective pitch anticipator fails when the measurement of the potentiometer's relative position reaches the minimum (5%) or maximum (95%) thresholds, or when it varies at a rate in excess of 350% per second. The system's design mechanically impedes these thresholds from being reached unless the sensor fails.

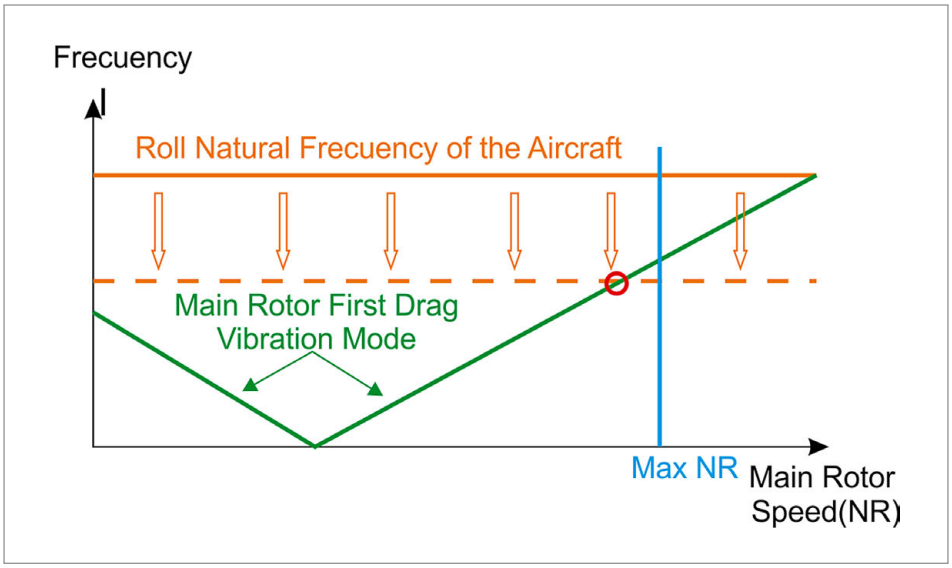

Figure 8. Effect of varying the aircraft's natural vibration frequency on the basic ground resonance graph

The DECU uses the potentiometer's position to determine the thrust that is going to be demanded at any given moment before said demand occurs. This readies the engine to supply the thrust that is demanded, which allows it to keep the rotor's rotation speed within its acceptable range.

Based on BEA's, Airbus Helicopters' and Turbomeca's experience, a fault in the anticipator potentiometer is usually a part of the fault sequence that is recorded after an impact with the ground. The remaining faults recorded are also regarded as probably resulting from the impact with the ground.

The information presented above rules out the possibility that the rotational speed of the main rotor may have changed, and thus that the blue curve in the graph shifted.

The inspections of the main rotor head and of the gearbox suspension (see Section 1.6.3) did not reveal any abnormal conditions nor evidence of any pre-existing faults or damage. Consequently, no significant changes affecting the main rotor head or the gearbox transmission are thought to have occurred, and thus the stiffness characteristics of the main rotor head remained unaltered.

The weight of the aircraft was within limits, and thus is not believed to have had any effect on the accident.

The condition of the landing gear was acceptable. Only the spring at the aft end of the left skid was slightly out of specification, though it is thought that it was bent during the accident.

The dampers on the landing gear were in good condition and the tests performed on them indicated that they were operating correctly. Thus, they are not believed to have played any role in the accident.

The marks found on the asphalt allowed investigators to determine where the helicopter's skids were resting. The right skid was resting entirely on the paved area, while the left was partially on the asphalt, its front part resting on the asphalt while the rear part was on the dirt. Due to the gradients of the two areas where the skid was resting, only its ends were being supported. The section in the middle was left suspended. It should also be noted that the weight on the rear part of the skid was only being supported by the spring, which is a highly elastic component.

When the pilot checked that the helicopter was properly supported by moving the cyclic lever slightly around the neutral point, the helicopter did not move, probably because its position on the ground was solid enough to give the appearance of being stable.

Other factors that could have affected its stability, such as the positions of the collective and cyclic controls, should also be taken into account.

After landing, the pilot must fully lower the collective pitch lever and keep it in that position.

The pilot must move the cyclic control lever into a position where he feels that the stability and vibration conditions are adequate, and then keep it there.

As was noted in Section 1.6.2, the friction on both levers was at its minimum setting. Under these conditions, the resistance offered to any movement is very low, meaning that the pilot may make an involuntary input to the controls that he is unaware of.

After landing, the pilot had to wait for the squad members to arrive. Once they did, two of them climbed onboard the helicopter, which forced the pilot to turn around to inform them that they had to exit the aircraft and unfold the Bambi bucket. Once this operation was complete, he turned his attention to testing the bucket, at which point one of the firefighters went underneath the helicopter to pull on the cable. It was at that moment that the helicopter began to move.

Several minutes elapsed between the landing and the time the helicopter went out of control. During this time the pilot had to move, turn around, give instructions, divert his attention, etc. In short, it seems likely that these actions, along with the long stretch of time that the helicopter remained on the ground, could have resulted in the pilot's providing involuntary inputs to the control levers, inputs that could have gone unnoticed due to the minimal resistance offered by the levers. Also during this time, the bucket was removed from its basket, which altered the aircraft's weight and the position of its center of gravity.

Any movements of the levers could have resulted in a substantial shift in the helicopter's equilibrium conditions. Moving the collective up would have increased the lift provided by the main rotor, which would imply an equal drop in the weight supported by the skids, leaving the helicopter in a condition commonly known as "light on its skids". Any shift in the cyclic lever's position, in contrast, would result a change in direction of the lift vector.

As for the resting position, it should be noted that the left skid was only resting on its ends, the front one on the asphalt and the rear one on the dirt. The rear one, in addition, was resting on the tip of the spring, which is a highly elastic component. Under these conditions, the support provided by the skid is not at all solid due to the elasticity of the spring.

This could have affected the aircraft's natural frequency vibration curve, causing it to shift downward (see Figure 8), with the ensuing reduction in the margin of separation between the curves.

These could have been the conditions present when the test of the Bambi bucket was being carried out. It is likely that over the course of the test, the pilot could have moved one of the control levers inadvertently, and that that motion of the controls could have been enough to negate any separation in the curves and start to destabilize the aircraft.

2.6. Analysis of the wreckage and marks on the ground

The marks left on the ground and the positions of the debris were used to try to determine the aircraft's position when the pilot lost control, as well as its subsequent motion and any impacts.

The two parallel marks found on the asphalt were in the area where, according to the eyewitnesses, the aircraft landed. It was oriented toward 265°, which matches the course the pilot said he took. Also, the distance between the two marks, a little over 2 m, is practically the same as that between the helicopter's skids. It may be concluded, then, that these marks were left by the helicopter's skids and indicate the point where it landed.

Behind the mark left by the right skid was another mark, elliptical in shape (see Figure 4), next to which was found the part of the right skid that broke off, as well as the rear crossbar from the landing gear. This mark was left mainly by the part that broke off the rear crossbar.

The preceding findings and the eyewitness statements indicate that the helicopter started moving slightly forward and then backward, leaving the faint marks mentioned earlier, before rising off the ground.

It must have been in these first few instants when the firefighter who was going to do the opening test on the Bambi bucket grabbed the right skid. The helicopter was swaying back and forth just off the ground with the firefighter hanging onto the skid for some time. When he released the skid to get away, there was an abrupt change in the forces acting on the aircraft. This caused the tail to descend suddenly, making it possible for the tail rotor to impact against the edge of the gradient, breaking its blades and causing the rotor to detach.

Both the skid and the tail guard at the bottom aft end of the fuselage are designed to keep the tail and the blades on the anti-torque rotor from striking the ground. Despite this, in this accident the blades on the anti-torque rotor did strike the ground.

An analysis of the geometry of the helicopter tail and the features of the accident site revealed that it was possible for the tail rotor blades to reach the ground without this being prevented by the tail skid or the tail guard. This was possible with the helicopter facing southwest and the tail over the incline.

It was precisely some of these detached fragments of the tail rotor blades that impacted the back of the firefighter who had been underneath the helicopter as he tried to get away.

After losing the tail rotor, the helicopter yawed sharply to the left, which worsened the aircraft's loss of control.

At some point during this turn the helicopter fell on its right skid, causing it to break.

The tail guard broke when it impacted against the edge of the incline during the helicopter's first rotation, though it could not be determined whether this occurred at the start or end of the rotation.

The helicopter continued rotating to the left, resting on the broken end of the rear crossbar and on the tail skid, which left a faint mark on the asphalted area. After making practically one entire rotation in this position, the aircraft turned over on its right side.

It was as it fell over that the main rotor blades impacted the ground, causing them to break and detach.

After falling on its side, the helicopter came to rest on the parts of the blades that remained attached to the main rotor, on the end of the rear crossbar and on the right horizontal stabilizer.

Since the main rotor was still turning under power at this time, on striking the ground it gripped it, as a result of which the helicopter started turning counterclockwise as seen from above, making a complete turn that left the circular mark made by the end of the right horizontal stabilizer.

2.7. Pilot's actions. Friction setting

In its Flight Manual the helicopter manufacturer underscores the need to adjust the friction settings on the cyclic and collective levers during the various phases of flight, noting that these need to be adjusted to provide the pilot with a feel for the movement of these flight controls.

The friction setting modulates the controls' resistance to movement, helping the pilot feel the inputs he is providing while offering reference points on the amount of input being applied. The resistance to motion offered by the friction also makes it so that any inadvertent movement of the controls by the pilot does not go unnoticed.

In addition, after landing and once the controls are put in a neutral position, the friction keeps them from moving by themselves, as might happen if the pilot has to release one of them, such as to signal personnel outside the helicopter who are awaiting instructions.

It is well-known that having little resistance to movement in the control levers favors over-control, something that is particularly relevant when the pilot reacts suddenly, as might be the case when responding to some abnormal situation. In contrast, the right amount of friction provides an artificial sense of the range of motion, making it easier to move the levers just the desired amount, and thus to control the helicopter.

In the accident analyzed herein, once the helicopter became unstable, the pilot acted to regain control but was unable to do so, possibly due to three circumstances:

- Limited dimensions of the landing area. The presence of obstacles around much of the perimeter of the landing area handicapped the pilot, forcing him to immediately correct any movement toward said obstacles.
- The lack of friction in the controls, which made it easier for the pilot to overcorrect for the aircraft's movements.
- The firefighter holding on to the right skid, which doubly hampered the maneuvers: by limiting the actions of the pilot who, knowing he was underneath the helicopter, was afraid of injuring him; and by the variable loads on the aircraft caused by the firefighter.

3. CONCLUSIONS

3.1. Findings

- The pilot had the license and ratings required for the firefighting tasks he was engaged in.
- The aircraft had valid documentation and had been maintained in keeping with its maintenance program.

- Communications between the pilot and the squad leader were not fully effective.
- The choice of landing spot did not fully adhere to the instructions contained in the operator's Special Operations Manual.
- The dimensions of the landing area were below the minimums recommended by the operator in its Operations Manual.
- The aircraft landed with the left skid partially resting on the asphalt and partially on dirt, and with the aftmost part of the tail over the incline between the two roads.
- While carrying out the test of the opening system on the Bambi bucket, the aircraft destabilized.
- No evidence was found of any pre-existing fault or malfunction in any aircraft system.
- The destabilization probably occurred as a result of the characteristics of the ground on which the skids were resting, and of some involuntary movement of the cyclic and collective controls
- The friction on the cyclic and collective controls was at its minimum setting.
- While trying to control the aircraft's movements, the pilot likely provided excessive inputs to the control levers.
- The firefighter who was testing the Bambi bucket held onto the helicopter's right skid when it became unstable.
- The anti-torque rotor struck the edge of the incline, causing its detachment and the total loss of control of the aircraft.

3.2. Causes

This accident resulted from a lack of compliance with the landing procedures, which caused the helicopter to become unstable while on the ground. This destabilization was probably due to the uneven support provided by the skids and to an involuntary movement of the helicopter's control levers.

Contributing to this accident were:

- The reduced dimensions of the landing area.
- The performance of the test on the Bambi bucket's opening system.
- The friction setting on the cyclic and collective control levers.
- The variable loads associated with the worker hanging from the skid.