DATA SUMMARY

LOCATION

Date and time	**Tuesday, 28 November 2007; 14:25 local time**
Site	**Asprella, Elche (Alicante)**

AIRCRAFT

Registration	**EC-FOA**
Type and model	**EUROCOPTER AS 350 BA**
Operator	**TAF Helicopters**

Engines

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

CREW

Pilot in command

Age	**30 years old**
Licence	**Commercial helicopter pilot**
Total flight hours	**2,505 h**
Flight hours on the type	**1,198 h**

INJURIES

	Fatal	Serious	Minor/None
Crew		**3**	
Passengers			
Third persons			

DAMAGE

Aircraft	**Major**
Third parties	**Fence and several mandarin trees**

FLIGHT DATA

Operation	**Aerial work – Commercial – Other**
Phase of flight	**Maneuvering**

REPORT

Date of approval	**28 October 2009**

1. FACTUAL INFORMATION

1.1. History of the flight

The aircraft, with three people aboard, the pilot, a power line technician and a Wescam camera operator, took off from an area near the town of Rojales (Alicante) for the purpose of continuing with inspection work begun a few days earlier on the Rojales-Elche power line.

Once airborne, they proceeded to tower number 230 of said line, where they arrived 10 minutes into the flight.

They started the inspection work on this tower, hovering a few meters away and some 15 m above the ground. They then proceeded to tower number 231, checked it and continued flying toward tower 232. Just as the pilot reduced speed and was about to commence hovering, he heard the main rotor low RPM aural warning. He immediately looked at the RPM gauge and noted that the needle was below the green arc as he felt the engine come to a stop.

The aircraft began to lose altitude quickly, giving the pilot only sufficient time to operate the controls to separate the aircraft as much as possible from the power line and to ease the impact with the ground. The aircraft impacted the terrain violently at an almost level attitude. Even though the skids broke into several fragments, the aircraft remained upright.

The pilot and camera operator were able to exit the aircraft by the right door. The line technician, who was seated in the front LH seat, complained of severe back pain. Since there was no apparent danger of fire, he remained in the cockpit.

Once emergency services reached the accident site, they deemed it opportune to extract the line technician while still in the seat so as not injure him further. Doing so required detaching the LH door and removing the two front seats.

All three aircraft occupants were subsequently evacuated to a hospital in Elche.

1.2. Injuries to persons

The impact of the aircraft with the ground was strong, involving a strongly vertical drop. All three aircraft occupants received injuries as a result, mainly to the back, which required transporting them to a hospital in the city of Elche, where they remained for treatment for over 48 h.

1.3. Damage to aircraft

As a consequence of the strong impact with the ground, the aircraft's landing gear was bent aft and upward. The skids broke into several fragments, while the two crossbars were compressed against the belly of the aircraft. The aircraft structure was also severely affected. A large number of cracks and deformations were present, most notably on the lower part of the fuselage, where the two structural crossbeams that run parallel to the helicopter's longitudinal axis were almost completely fractured. The tail cone was wrinkled and bent, especially at the rear. One of the tail rotor blades had broken at the root.

The Wescam camera, which is located outside the helicopter on the right side, was seriously damaged by an impact first with a tree and then with the ground.

From the damage sustained by the aircraft, it can be deduced that the impact with the ground was essentially vertical.

1.4. Other damage

The aircraft crashed in a mandarin grove, impacting against several of the trees and breaking off a number of branches. The tail of the aircraft also knocked down a 4-m section of the fence that enclosed the field, including one of the posts.

1.5. Crew information

The pilot held a commercial helicopter pilot license valid until 7 December 2010, along with the following ratings:

- AS350/350B3. Valid until 11 Nov 2008
- AS355/355N. Valid until 21 Feb 2008
- BO105/105LS/105CBS. Valid until 22 Apr 2008
- EC130B4. Valid until 13 Dec 2007

The pilot's flight activity over the previous 90 days had been as follows:

- Last 90 days: 203:40 h
- Last 30 days: 69:53 h
- Last 24 hours: 3:10 h

He had a total of 2,505:37 h of flying experience, of which 1,198:37 had been on aircraft of the type involved in the accident.

1.6. Aircraft information

1.6.1. *Frame*

Manufacturer:	EUROCOPTER
Model:	AS 350 BA
Serial No.:	2626
Year of manufacture:	1992
Registration:	EC-FOA
MTOW:	2,100 kg

1.6.2. *Engines*

Number:	1
Manufacturer:	TURBOMECA
Model:	ARRIEL 1B
Serial number:	4383

1.6.3. *Maintenance*

Total flying hours (airframe):	6,065:05
Date of last inspection (100 h) (engine):	2/11/2007 with 5,741:15 h
Hours since last inspection (engine):	82:13 h

1.6.4. *Fuel*

Since the base of operations did not have permanent fuel facilities, the aircraft was refueled from drums which had been filled previously at the airport in Alicante.

The aircraft was fully refueled with JET A1 fuel before taking off on the accident flight.

1.6.5. *Height-velocity chart*

The height-velocity chart defines an area to be avoided during aircraft operations since, in the event of an engine failure, the combination of height-velocity is insufficient to ensure a safe emergency landing. The diagram has two fixed points, A and B, and two others, C and D, which depend on the weight of the aircraft, on the altitude at which it is flying and on weather conditions.

The weight of the aircraft the day of the accident was as follows:

• Empty weight	1,243.00 kg
• Filming equipment	136.82 kg
• Pilot	80.00 kg
• Technician	80.00 kg
• Operator	80.00 kg
• Fuel	341.60 kg
Total weight	**1,961.42 kg**

The temperature was 10 °C and the elevation of the accident site was about 100 ft.

Using these data and the graphs in the aircraft's flight manual, the restricted area was calculated, as shown in Figure 1 and defined by points A and B (fixed) and C and D (variable, in red).

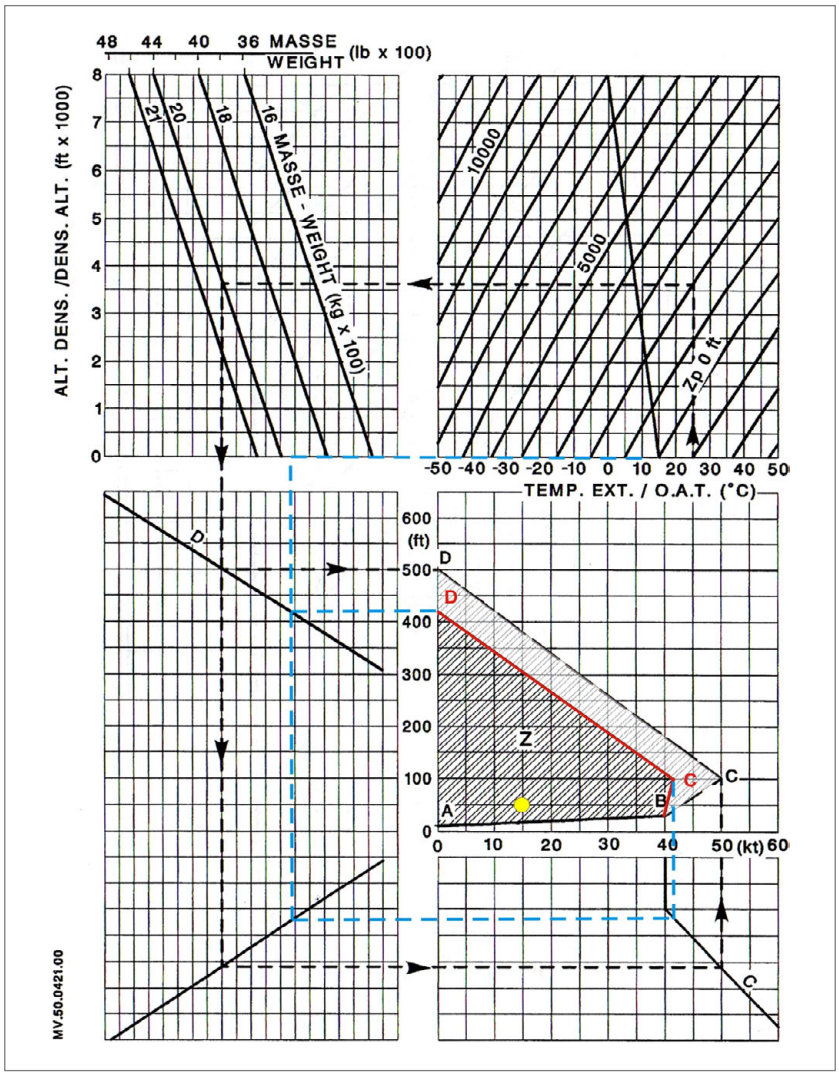

Figure 1. Height-velocity chart

At the time of the engine stoppage, the aircraft was at an height of 50 ft. It had a very low translational speed since it was decelerating in preparation for hovering, being the speed estimated of 15 kt. With these data the point where the aircraft was flying at that time is shown in Figure 1 by a yellow circle. As shown, under these conditions the aircraft was flying inside the shaded, restricted area.

It can also be deduced from the chart that, given the conditions that existed on the day of the accident, the minimum hovering height was 425 ft.

1.7. Wreckage and impact information

As can be seen in Figure 2, the aircraft impacted the ground in a mandarin grove. The aircraft's longitudinal axis was practically aligned with the rows of trees and lay between two of them. The aft part of the aircraft's tail protruded slightly outside the limits of the grove.

Figure 2. Sketch of the accident site

The aircraft wreckage was some 9 m away from the nearest cable of the Rojales-Elche power line that was being inspected. Its longitudinal axis was at a 25° angle with the power line.

No part of the aircraft detached during the impact. Only the left door and the two front seats were removed by emergency personnel. The aircraft retained its integrity. There were no signs of any fuel, oil or hydraulic fluid leaks.

The belly of the helicopter was resting on the ground since the skids had broken off and the crossbars to which they attach had bent aft and upward. The Wescam camera that was located on the right side of the helicopter had impacted a tree and then the ground, as a result of which it was severely damaged.

During the fall, the vertical stabilizer's protective shroud, which is located in the lower part of the tail fuselage, impacted against and dragged the perimeter fence surrounding the field, breaking it and bending one of its metal posts, which was subsequently cut by rescue services.

The main rotor blades did not show appreciable damage. Even though the tops of the trees near the aircraft protruded above the plane of the rotor disc, very few branches had been cut.

One of the tail rotor blades was found broken near its root, although no clear impact marks were noted on its surface.

The cabin only showed considerable damage in the front, where the lower left glass had broken. Despite this damage the cabin retained its shape.

Many of the trees near the area where the aircraft fell had some of their branches cut as a result of the impact by the helicopter fuselage.

Once the aircraft was removed, the marks left on the ground could be seen. There were two considerable imprints 2.4 m apart, made by the two skids, the left one measuring 1 meter and the right one 1.2 m. They were noticeably parallel to the longitudinal axis of the aircraft. In front of these imprints, at a distance of 1 m and 3.8 m, there were two other marks. The first corresponded to the initial impact point of the nose of the aircraft, while the second resulted from the final contact. There were marks between them and faint drag marks, though without any obvious continuity.

The direction, depth and length of the imprints left by the aircraft as a result of its impact with the ground, as well as the damage to the aircraft itself, point to a considerable vertical speed and a minimal horizontal speed at the time of impact.

1.8. Inspection of aircraft

1.8.1. *Cabin*

The positions of the switches inside the cockpit were as follows:

BAT	OFF
Fuel pump	ON
GEN	ON
Anti-coll Lt	ON
Pos. Lts	ON
HYD. Test	ON
HORN	ON
Pitot	ON
ATT	ON
Gyro Compass	ON
Remaining switches	OFF

The collective control was near its lowest position. The rotor brake handle was in its normal in-flight position, and the throttle was in its flight position. The fuel shut-off valve actuating handle, which must be wire-sealed open, was slightly shifted from that position with the wire seal broken.

It was noted that the cyclic and collective controls moved without any difficulty. Continuity was established with the swash plate. No abnormalities were noted in the main rotor head.

The pedals could be moved throughout their range of motion and there was continuity between the pedals and the tail rotor pitch control system.

The cables connecting the video receiving and recording equipment and the monitors for the pilot and electric grid technician were cut near the main rotor brake and throttle handles and the shut-off valve. The microphone cable was also cut.

1.8.2. *Transmission and engine compartments*

In the transmission compartment, the two front bars of the set of four that attach the transmission to the helicopter were broken. The fuel filter was in good condition and the fuel shut-off valve was in an almost fully-open position. To this end, it is worth noting that this valve closes progressively, meaning that in order for it to fully close, it is necessary to move the actuating handle to its travel limit. The valve was cycled as part of the investigation. It operated normally.

No fuel or oil leaks were detected in the engine compartment. In the control unit, the metering needle that governs the different engine operating positions was found in the 52° position, labeled as "Pleine Puissance" (Full Power). The anticipator mechanism was confirmed to be functioning properly.

The fuel lines between the fuel control system and the engine were opened to reveal that a small quantity of fuel remained inside them.

1.8.3. *Fuel system*

The fuel system was inspected from the tank to the emergency shut-off valve. No obstructions were noted in the lines and the fuel pump was verified to be operating normally. The tank was properly ventilated.

1.8.4. *Fuel*

Several fuel samples were taken, one from the drum used to refuel the aircraft on the day of the accident, another from the aircraft's fuel tank, and a third, low-volume sample, from the engine lines that were opened during the inspection at the accident site.

Two tests were conducted at the accident site using a Shell Water Detector capsule. Both results were negative.

1.9. Survival aspects

The aircraft reacted to the impact in a satisfactory manner. The harnesses firmly restrained the bodies of the occupants, and the seats sustained the elevated vertical loads of the impact with the ground. The cabin maintained its shape and the doors did not jam, which allowed the occupants to quickly exit the aircraft.

There were also no liquid leaks of any kind, whether of fuel, oil or hydraulic fluid, which contributed to the absence of a fire.

1.10. Tests and research

1.10.1. *Eyewitness statements*

Pilot

The pilot stated that the helicopter had been stationed in the town of Rojales (Alicante). They waited for the proper clearance to fly within the Alicante CTR since the line to be inspected was inside said zone.

While they waited, they held a briefing on the layout of the line and the points to be inspected.

Engine start-up was normal and the parameters were correct at all times.

They took off and headed toward the first line tower to be inspected, which took some 10 minutes of flight time.

They inspected the first tower, then the second one and afterwards they proceeded to the third. As they closed the gap and he started to reduce speed to start hovering, he heard the low RPM warning. He was looking outside at the time and he turned to see the rotor RPM indicator needle below the green arc. He felt the helicopter start to descend and he moved the cyclic control so as to move the helicopter away from the line.

At that very moment he heard the engine come to a complete stop, sounding like it does when it is stopped on the ground.

The helicopter kept falling and he tried to cushion the final impact.

Once on the ground, everything was silent except for the noise of the blades brushing against the tops of the trees. The line technician was complaining about his legs. He removed the right door and tried to help the camera operator, who was able to exit.

He saw people coming to their aid and he asked them to call emergency services. He contacted the control tower at Alicante airport and his company to inform them of the accident.

Firefighters arrived some 10 to 15 minutes later and helped the line technician, which required accessing the interior of the cabin via both front doors and cutting the seats.

When asked if he had actuated the HYD test, horn and pitot switches, he replied in the negative, stating that the only thing he disconnected after the impact was the battery switch.

Camera technician

He stated that on the day of the accident, the wind was calm and the outside temperature was 9 °C or 10 °C.

In keeping with the briefing, the plan was to film between 30 and 40 towers.

The engine start was normal and they proceeded to the first tower, which took some ten minutes. The flight was normal. His harness was fastened and he was wearing warm clothes.

As they neared tower number 232, he noted a slight tilt, heard a high-pitched sound and felt something out of the ordinary. He then felt the engine stop and the helicopter start to fall at a slight bank angle.

The impact with the ground was very hard. The only sound he heard afterwards was the main rotor blades brushing against the tree branches.

As for the nature of the work they were conducting, he stated that it consisted of video recording the power line (cables and towers) as well as the ground beneath. The line technician has a monitor on which he watches the images from the camera and comments on their condition, noting whether any maintenance work is required. Both the video and the audio are recorded for subsequent analysis by the owner of the electric line.

1.10.2. *Analysis of the sound*

The original audio tape of the work being performed was sent to a laboratory for a spectrum analysis, in the hopes of determining the rotational speeds of different helicopter components, such as the main rotor, the main reduction gear, the different compressor stages, etc. The last 260 seconds of the flight were analyzed, with a special focus on the last 13 seconds.

The frequencies in the range 0-17000 Hz were analyzed. In the time period before the loss of power, the rotational speed of the main rotor was between 380 and 386 RPMs, while that of the compressor varied between 91.6 and 95.5%. These are normal values for the parameters in question.

At the time of the power loss, the main rotor was rotating at 384 RPMs and the compressor at 95.5%. Three seconds later these parameters had dropped to 240 RPMs and 40%.

The main rotor low RPM alarm sounded when the main rotor frequency was at 18Hz, equivalent to 360 RPMs, in keeping with design values.

1.10.3. *Engine inspection*

The engine was inspected at the manufacturer's facilities.

The first inspection conducted was visual, and revealed the following:

- No external damage was noted.
- No wear was noted on the axial compressor blades.
- Shiny particles were noted in the blades of the axial and centrifugal compressors.

- A permeability test of the injection wheel was performed with a value of 7.9 seconds, which is within specifications.
- No chips were found in the magnetic plugs.
- All rotating components were verified to rotate freely.
- No damage was noted on the trailing edges of the free turbine blades.
- The freewheel was working normally.
- The cable on the right side of the spark plug was worn near the connector.

A boroscopic inspection was subsequently performed and revealed the following:

- The combustion chamber was in good condition.
- The first stage of the gas generator turbine was in acceptable condition. It was noted that two blades were missing a very small amount of material.
- No damage was noted on the injectors.
- No damage was noted on the trailing edges of the centrifugal compressor blades.

A one-hour operational bench test was conducted next, during which five engine starts were performed and which included the following checks:

- Preliminary vibration check: satisfactory.
- Overspeed control: satisfactory.
- Oil pressure: satisfactory.
- Bleed valve opening threshold: satisfactory.
- Re-injection: satisfactory.
- Stoppage test: satisfactory.
- 76 mdaN torque, which is 96% of nominal. This was out of specification (100% ± 2%).
- Engine operation: satisfactory.
- Purge valves: no leaks.
- The engine was stopped using the emergency shut-off valve on the test bench. It was noted that the amount of fuel remaining in the lines between the fuel control and the injectors was similar to that found during the inspection at the accident site.

Finally, the fuel control unit and valves (start drain valve and injection drain valve) were removed so they could be bench tested.

The results for the fuel control unit were satisfactory with the exception of the acceleration curve, which had a point slightly outside the limit.

The results for the valves were likewise satisfactory, except for a loss of pressure between the inlet and outlet of the injection drain valve, which was outside the limit.

In conclusion it should be noted that the minor anomalies and out-of-specification parameters found in the engine are not enough to explain the stoppage experienced by the engine.

1.10.4. *Fuel analysis*

The fuel samples taken at the accident site were sent to a laboratory for analysis, which concluded that the samples were within specifications.

2. ANALYSIS

2.1. Analysis of the impact and aircraft wreckage

As noted in Section 1.7, the imprints left in the ground by the aircraft during the impact, as well as the damage found to the landing gear and to the aircraft fuselage, reveal that at the time of the impact with the ground the aircraft had a low translational speed and a high vertical speed.

In addition, the slight damage to the tree branches that protruded above the plane of rotation of the main rotor disc, as well as the absence of impact marks on the main rotor blades, indicate that the main rotor was turning at a low speed when the aircraft made contact with the terrain.

The inspection of the flight controls revealed that continuity existed with the main rotor swash plate and with the pitch control mechanism of the tail rotor, and that these systems were operating properly in response to control inputs. The possibility of a malfunction in the flight controls during the accident flight can, therefore, be dismissed.

As for the cockpit switches, it should be noted one of them, the HYD. Test, was found in the ON position when it should have been OFF. Since the pilot stated that this switch was disconnected, the most likely conclusion is that it must have been inadvertently repositioned by members of the emergency teams while rescuing the line technician.

As for the shut-off valve handle, which was found slightly out of its normal position and with the wire that seals it in that position broken, there are two possibilities. Either that, as with the switches, it was inadvertently actuated by members of the rescue team, or that a motion by one of the crew members pulled on one of the cables connecting the video and audio recording equipment and the monitors, which in turn pulled on the fuel shut-off valve handle and changed its position. In this case there is also the possibility of the handle being shifted later on by the emergency services towards the closed position.

Concerning the fact that a similar fuel quantity was found in the circuit segment that goes between the fuel control and the injectors, both after the accident and also after performing the engine stopping in the test bench by means of the shut off valve, we must bear in mind that when an engine stop occurs, by normal procedure or by using

the shut off valve, a fuel extraction of this part of the circuit is carried out by introducing pressure air coming from the compressor. So the fact that a certain fuel quantity remains in this part of the circuit is due to a slightly defective cleaning system, which has no relation at all with the engine stop, neither with the way it occurred.

The alteration found inside the cockpit after the accident due to the emergency services actuations prevented from finding evidences as to clarify which one of the both supposed events above mentioned did actually happen. Therefore, though the last hypothesis would thoroughly explain how the engine became to a stop during flight, it is considered that no evidences enough have been found to certify that this was the cause of the engine stop.

2.2. Analysis of sound spectrum

The sound spectrum analysis of the last 260 s of the flight revealed that up to the time of the initial engine power loss, all engine and main rotor operating parameters were completely normal.

From that moment on, the turn rates of the components analyzed (compressor, reduction gear and main rotor) decreased rapidly in a manner fully consistent with an engine stoppage.

2.3. Engine analysis

As noted in Section 1.6, the engine had been maintained in accordance with the approved maintenance schedule.

The spectrum analysis of the sound recorded during the accident flight, along with the statements of the pilot and camera operator, indicate that the aircraft engine stopped in flight as the pilot was reducing speed prior to hovering.

The inspections of the fuel, fuel system and engine, as well as the operational bench tests to which the engine was subjected, did not reveal the existence of any abnormalities which could have led to an engine stoppage.

2.4. Analysis of the operation

As shown in Figure 1 (height-velocity chart) included in Section 1.6.5, practically the entirety of the flight to inspect the power line was conducted inside the unsafe area of the height-velocity chart.

Operating outside this area requires a combination of height-velocity such that flying at the height of the cables would require a speed of at least 40 kt, and hovering would require a minimum altitude of 425 ft.

Operating under such conditions would make the inspection of power lines completely unviable with the methods currently in use, since it would require flying either too fast or too far away.

3. CONCLUSIONS

The accident in question resulted from an engine stoppage during a flight to inspect a high-voltage power line. The cause of the stoppage could not be determined.

The fact that the aircraft was operating inside the restricted area of the height-velocity chart contributed to the severity of the accident.