BEA
Bureau d'Enquêtes et d'Analyses
pour la sécurité de l'aviation civile

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SAFETY INVESTIGATION REPORT

Accident to the ROBINSON R44 II registered F-HLOU on 31 October 2023 at Salazie (La Réunion)

Time	08:48[1]
Operator	Private
Type of flight	Non-commercial sightseeing flight
Persons on board	Pilot and three passengers
Consequences and damage	Pilot and passengers fatally injured, helicopter destroyed
This is a courtesy translation by the BEA of the Final Report on the Safety Investigation. As accurate as the translation may be, the original text in French is the work of reference.	

Loss of control in flight, collision with the terrain

1 HISTORY OF THE FLIGHT

Note: the following information is principally based on statements and recordings from security cameras located on the helicopter base.

The pilot, accompanied by three passengers, took off at 07:15 from Saint-Paul L'Éperon heliport[2] for a first local flight of around 55 min overhead La Réunion. At the end of the flight, the pilot returned to land at the heliport, where he topped up the main fuel tank from a drum.

At around 08:20, the pilot and three new passengers, one of whom was his wife, boarded the helicopter. At 08:33, the pilot took off heading north for a flight over the island.

The pilot of another R44, registered F-GZBD, coming from Mazerin (see Figure 1) at an altitude of 4,500 ft[3] and heading towards the Le Voile de la Mariée waterfalls, heard the pilot of F-HLOU on the radio announcing that he had arrived at Piton d'Enchaing via Col des Bœufs and was also heading towards Le Voile de la Mariée. He positioned himself behind F-HLOU at a distance of approximately 500 m. He saw F-HLOU, approximately 600 ft below him, flying along the western slope of the mountain, passing the waterfalls and heading towards Le Bois de Pomme.

At 08:47, as F-HLOU approached the pass to cross the ridge and enter the gorge to proceed to the Trou de Fer, the pilot of F-HLOU announced over the radio, "Turbulence, Turbulence," and then a few seconds later, "PAN PAN." The pilot of F-GZBD saw the helicopter veer to the left. The pilot of F-HLOU again announced "PAN PAN" during the turn. The pilot of F-GZBD, who had also heard the "LOW NR" warning in the background during both messages, saw a decrease in the rotation speed of the main rotor, followed by the sudden fall of F-HLOU, which collided with the mountainside and slid down the slope before coming to a stop. The pilot of F-GZBD gained altitude and contacted the Saint Denis airport controller by radio to report the accident.

[1] Except where otherwise indicated, the times in this report are given in local time.
[2] The heliport belonged to HELILAGON.
[3] The glossary of abbreviations and acronyms frequently used by the BEA can be found on its web site.

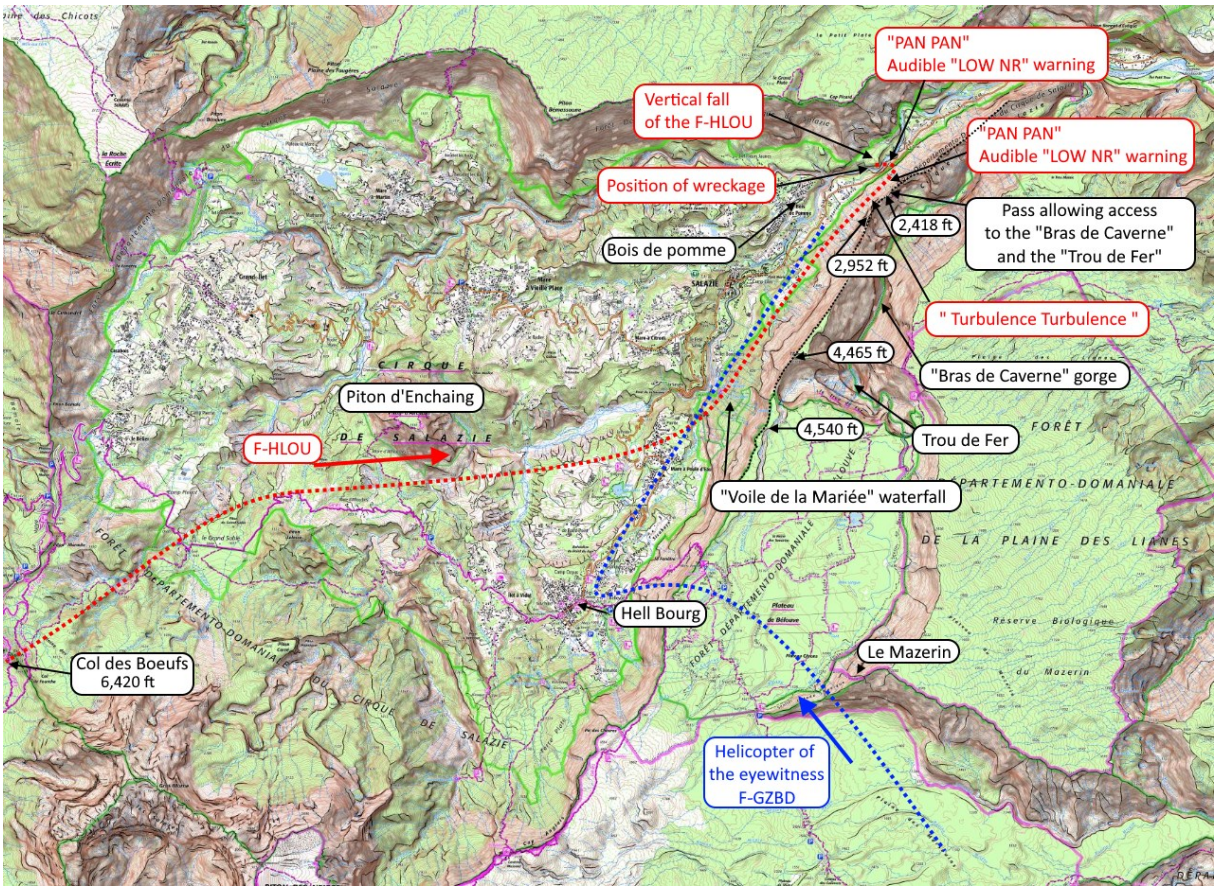

Figure 1: flight paths followed by F-HLOU and F-GZBD (reconstructed from statements)
(Map source: Géoportail, altitudes indicated are AMSL altitudes of the terrain)
(The values indicated correspond to the height of the ridge)

2 ADDITIONAL INFORMATION

2.1 Examination of site and wreckage

2.1.1 Accident site and initial impact

The accident site was located at an altitude of 1,150 ft, on the eastern slope of the mountain in the Mât river gorges (left bank) at the exit of the Salazie cirque, at Le Bois de Pomme, and in the direction of Saint André. The helicopter first struck the vegetation and then the ground 30 m above the area where the main wreckage was lying.

Figure 2: location of wreckage and initial impact
(satellite image: Google Earth, left photo: BEA)

2.1.2 Examination of wreckage

The first impacts were observed in the branches of a tree, which showed signs of interference (tears, scars) with the airframe or rotating parts of the helicopter. No branches were found cleanly severed.

Several pieces of the main rotor blades, the tail rotor (TR), the tail gearbox (TGB), the tail boom, some airframe components, and one of the helicopter's skids were present on the slope. The location of this debris was consistent with the path followed by the helicopter as it slid down the slope after colliding with the terrain.

Observations of the interaction between the main rotor blades and the vegetation seem to indicate low rotor torque at the moment of collision.

The TGB was separated from the drive shaft, and the marks found on the TGB casing seem to indicate that it was not rotating at the time of the rupture.

The main part of the wreckage included the badly damaged airframe, the engine, the two fuel tanks, which were ripped open and had separated from the airframe, the main gearbox (MGB) and the rotor head, to which part of the blades was still attached.

The deformations on the elastomer cones of the blade roots were consistent with a low rotation speed of the main rotor during the collision with the vegetation.

The rotor mast turned freely and no blockages were observed on the MGB. The freewheel was functional. The four belts transmitting drive from the engine to the MGB and the TGB were found disengaged from their position on the pulleys, and one of the belts had broken, most likely as a result of the accident. The belts showed no signs of overheating or excessive rubbing.

Observation of the deformations on the clutch system found that it was at least partially engaged at the time of the accident.

The ruptures observed on the drive linkages from the engine to the rotating components were sudden breaks, consistent with the collision with the ground. The drive system was most likely functional before the accident.

The flight control channels (yaw, cyclic, collective) were reconstructed. All of the ruptures observed were sudden and can be associated with the collision with vegetation and the ground. No anomalies were observed, and the flight controls were continuous and functional before the accident.

The upper part of the centre console in the cockpit, which has the flight instruments and warning lights, was not found. However, it was observed that:

- the dual controls were not installed for this flight;
- the throttle lever was found in the “full throttle” position;
- the collective pitch control was found in the high pitch position. The deformation of the friction device indicated that the observed position of the collective pitch control was the one just before the collision with the ground;
- the friction control was found in the maximum friction position. This position was very probably modified during the accident: the deformation of the friction device and the marks observed on the lever indicate that the friction device was not in the maximum friction position at the time of the accident;
- on the collective pitch control, the switch for activating the automatic engine power control system (governor) was in the “ON” position (normal position during flight).

2.2 Pilot information

The 44-year-old pilot held a helicopter private pilot license (PPL(H)) obtained in 2005 and the R44 type rating obtained in 2022. He had logged a total of 230 flight hours.

The pilot had stopped flying in 2006 for personal reasons, when he had logged approximately 90 flight hours. In 2021, he renewed his license along with the R44 type rating after approximately 15 hours of training.

The pilot then resumed flying with the Vol Ensemb association based in Saint-Pierre in November 2021. From that date until the accident (a period of 23 months), the pilot completed 143 flights within the association, representing a total of 128 flight hours.

During the austral winter of 2023, the pilot contacted HELILAGON, based in Saint Paul L'Eperon, which offered F-HLOU for dry lease. On 24 August 2023, he performed an evaluation flight[4] with an instructor from the company. This flight was deemed satisfactory and a dry lease contract was drawn up at the end of August between the pilot and HELILAGON. Between 24 August and the accident, the pilot completed 10 flights, totalling a flight time of 9 h and 30 min all on F-HLOU.

Over the previous two years, most of the pilot's flights were on R44s, flying locally over La Reunion. These were mainly sightseeing flights lasting no more than an hour above the iconic sites of La Reunion, departing from Saint-Pierre Pierrefonds aerodrome when the pilot used the R44s belonging to the Vol Ensemb association, or from Saint Paul l'Éperon heliport when he leased the R44 from HELILAGON.

The pilot was in the habit of carrying out the walk-around inspections of the helicopter, welcoming passengers upon their arrival on site, giving the safety instructions, and then proceeding with boarding. Upon returning from the flight, he would refuel the helicopter himself.

2.3 Context of flight

The flights carried out by the pilot were organized for the benefit of relatives, friends or acquaintances. The passengers only paid the cost of leasing the helicopter at the end of the flight. The pilot did not receive any remuneration. This practice allowed the pilot to gain experience.

2.4 Analysis of video recordings

2.4.1 Video from security cameras on HELILAGON base

The security camera recordings cover the period from 07:00 to 09:00 and establish the following facts:

06:50	Arrival of the three passengers and boarding of the helicopter
07:03	Take-off for the first flight
07:57	Landing at the end of the first flight
08:14	Refuelling of the main fuel tank (approximately three minutes) after bringing the trolley with the fuel drum to the helicopter
08:22	Boarding of the pilot, his wife, and two passengers
08:28	Main rotor and tail rotor start spinning
08:32	Hover, hover taxiing to the take-off area, then take-off
08:33	Helicopter leaves the camera's field of view

The analysis of the recordings confirmed that, after refuelling, the pilot did not drain the tanks. Approximately 10 min elapsed between the end of refuelling and engine start-up, and 16 min until the helicopter left the camera's field of view. No anomalies were visually detected.

2.4.2 Video footage from passengers on the first flight

Two of the three passengers on the previous flight made several video recordings during the flight.

[4] Flight including the emergency and operational procedures (organisation of refuelling, draining, storage of oil, securing fuel).

The spectral analysis of these video recordings[5] made it possible to characterize the helicopter's acoustic signature and determine the engine and rotor speeds during the flight phase filmed. This analysis did not reveal any anomalies in the operation of the engine, MGB, TGB, main rotor or TR.

The visual analysis of the recordings showed that, in the Trou de Fer and Bras Magasin waterfall areas (located southwest of the Salazie cirque), the pilot flew below the ridge line and along the slopes, very close to the vegetation, below the regulatory flight height of 500 ft.

2.5 Helicopter information

2.5.1 General information

F-HLOU was a Robinson R44 RAVEN II; its certificate of airworthiness was issued in August 2014. Its airworthiness review certificate was valid until 23 March 2024. The helicopter was based at Saint Paul l'Éperon heliport.

F-HLOU belonged to HELILAGON which dry leased it to pilots. This helicopter was not listed in the company's fleet, was not operated as part of HELILAGON's commercial transport activities and did not appear in their operations manual.

The helicopter was equipped with a Lycoming IO-540-AE1A5 engine which had logged 581 hours of operation.

The helicopter's continuing airworthiness was managed by a CAMO under contract with HELILAGON and maintenance was performed by a Part 66 mechanic with the R44 rating. The last 100-hour maintenance check was carried out on 22 September 2023. Since that maintenance check, 22 flights and 17 flight hours had been completed without any anomalies being recorded by the pilots in the helicopter's journey logbook.

2.5.2 Helicopter flight manual

2.5.2.1 Engine failure procedures

The helicopter flight manual states that in the event of an engine failure, the pilot must take the following measures (autorotation):

- immediately lower the collective pitch control to maintain rotor speed;
- obtain a speed of 70 kt (velocity minimum drag);
- adjust the collective pitch control to maintain the main rotor speed in the 97% to 108 range;
- select a landing area and, if altitude permits, position the helicopter facing into the wind;
- depending on the altitude, the pilot can attempt to restart the engine;
- if it has not been possible to start the engine, land by performing a flare[6].

2.5.2.2 Aural warning

The R44 has an aural warning associated with the rotor speed. This "LOW NR" warning is triggered when the rotor speed falls below 97%. This warning is inhibited if the collective pitch control is fully lowered.

[5] One of these corresponded to the landing, which made it possible to determine the condition of the helicopter at the end of the flight and, by extension, the condition of the helicopter before the accident flight.
[6] Action on approaching the ground consisting of pulling up the collective pitch control, reducing the descent speed combined with pulling back the cyclic pitch control to raise the helicopter's nose and reduce horizontal speed.

Note: the witnesses in the R44 registered F-GZBD heard the “LOW NR” warning in the radio messages transmitted, indicating that the rotor speed was below 97% and that the collective pitch control was not fully lowered (see paragraph 2.8.1).

2.5.2.3 Pre-flight draining

The helicopter has three drain points to check that there is no water in the fuel system: one for each of the two tanks, and the third on the gascolator located at the lowest point of the helicopter's fuel system. The helicopter flight manual states that draining must be performed before the first flight of the day and also after each refuelling operation.

2.5.3 Fuel tanks

The helicopter is equipped with two fuel tanks, the main tank (on the left) with a capacity of 30.5 US gal[7] (including 1 US gal of non-consumable fuel) and the auxiliary tank (on the right) with a capacity of 17.2 US gal (including 0.2 US gal of non-consumable fuel).

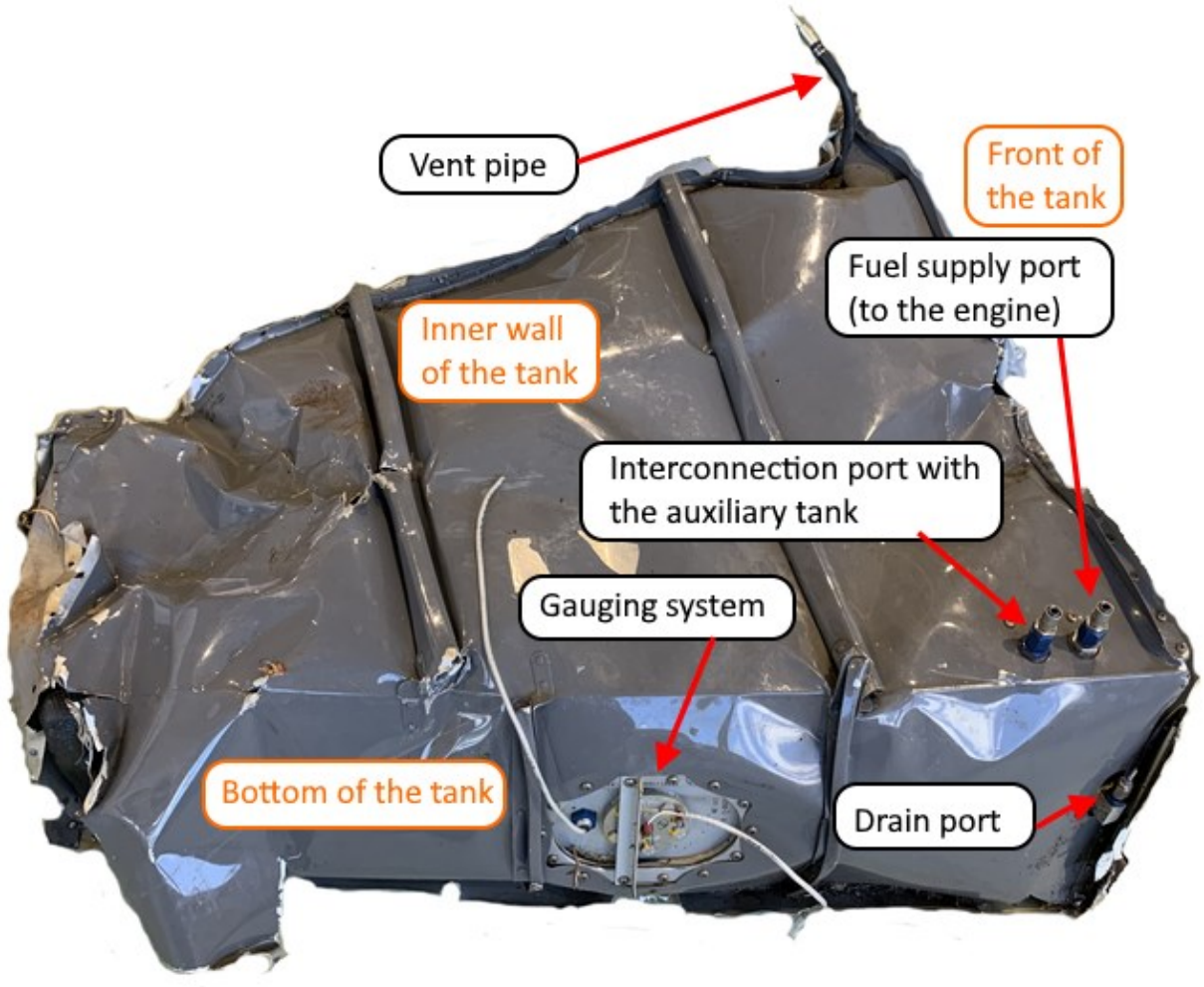

Figure 3: main fuel tank of R44 F-HLOU (source: BEA)

Each tank has a refuelling port (at the top) and can be drained independently. The fuel draining point is located at the front bottom of the tank at the lowest point[8]. The two tanks are permanently interconnected. The bottom of the auxiliary tank is positioned higher than that of the main tank,

[7] Anglo-Saxon unit of volume, the symbol being US gal. A US gallon corresponds to around 3.78 l.

[8] By design, when the helicopter is on the ground, the bottom of each tank slopes forward at an angle of 13°.

which allows the auxiliary tank to be emptied first. The fuel supply port to the engine is located on the main tank. It is located on the vertical inner wall of the tank, approximately three centimetres above the bottom of the tank and next to the connection port to the auxiliary tank. The two tanks have independent gauges, and the main tank has a low fuel level indicator. The fuel valve in the cockpit has only two positions: open or closed.

2.6 Additional examinations

2.6.1 Engine and components

The engine was disassembled and examined at the BEA. Despite substantial external damage resulting from the accident, the engine showed no signs of insufficient lubrication or abnormal wear.

The power and richness control systems were continuous at the time of the accident.

The tests that could be carried out on the ignition system did not reveal any anomalies prior to the accident.

Functional tests of the governor control unit did not reveal any anomalies.

No mechanical anomalies likely to explain an engine shutdown or malfunction in flight were detected.

2.6.2 Fuel system

The fuel system was continuous prior to the accident. The fuel valve was found in the open position. The examination of the electric pump and injectors did not reveal any anomalies prior to the accident.

The fuel filter, metering unit, injection system distributor (spider) and mechanical pump were examined in a specialized workshop. Several instances of damage were noted on some of these components, but all could be correlated with the helicopter's collision with the ground. After repairing this damage, tests carried out on the various pieces of equipment were not able to establish or explain any engine failure during the accident flight.

2.6.3 Analysis of fuel samples

Fuel samples

Six samples were taken:

- one from the main tank and one from the auxiliary tank at the site on the day of the accident;
- one from the main tank and one from the auxiliary tank the day after the accident;
- two samples from the fuel drum that the pilot had used for refuelling between the two flights:
    - one from the pipe at the outlet of the JAPY pump , which made it possible to recover a sample corresponding to the residual fuel present in the refuelling pipe and the fuel present at the bottom of the drum[9],
    - one from the surface of the drum contents after removing the JAPY pump.

[9] The length of the dip tube in the drum is 80 cm and the depth of the drum is 85 cm, leaving 5 cm of unusable fuel.

Analysis of fuel samples

The analysis of these six samples revealed that:

- the physical and chemical characteristics measured in each sample corresponded to the values specified for AVGAS 100LL fuel or to the values usually measured for this type of hydrocarbon;
- the chromatograms obtained were typical of AVGAS 100LL and did not show any contamination by another type of hydrocarbon;
- the most significant difference concerned the presence of free water[10] in the samples taken from:
    - the auxiliary tank of the wreckage (sample taken the day of the accident);
    - the main tank of the wreckage (sample taken the day after the accident);
    - the auxiliary tank of the wreckage (sample taken the day after the accident).

However, the sampling conditions suggest that the presence of water in the samples could be a consequence of the sampling itself.

Specific observations on samples taken from the drum

The sample recovered via the refuelling nozzle of the refuelling drum was single-phase (no "free water"). However, the dissolved water content in the fuel was 17,380 mg/kg which is very high[11].

The presence of free water is made possible when the amount of water in the fuel exceeds a certain level. This level is not defined as a specification. According to the laboratory contracted by the BEA, for a water content above 5,000 mg/kg, the appearance of "free water" is highly likely.

As the density of water is higher than that of the hydrocarbon in question, this volume of free water will be located at the bottom of the drum. When filling a tank, the time required for the free water to stabilize at the bottom of the tank varies depending on the type of filling (e.g. flow rate during the operation, quantity of fuel). According to this laboratory, this time could be a few minutes.

The sample recovered at the surface in the refuelling drum had a very low water content. This result is not necessarily inconsistent with the previous one. The volume of fuel, located above the volume of free water, will have a water content that is "dissolved" in the hydrocarbon that will vary depending on the height at which the sample is taken from the drum.

Note: although the conditions for taking the four fuel samples at the accident site were not optimal and may call into question the results of the analyses, particularly the presence of water in the fuel, the sample taken from the pipe connected to the JAPY pump mounted on the drum was taken in a nominal manner and can be considered representative of the nature of the fuel that was delivered to the helicopter at the end of the refuelling carried out by the pilot between the two flights.

The samples took a long time to be transported to mainland France. During this period, the fuel drum was emptied and returned to the fuel supplier. It was therefore not possible to carry out further tests.

[10] The term "free water" refers to a volume of water that is separate from the volume of fuel (two distinct phases).

[11] For AVGAS 100LL, a content of less than a few hundred mg/kg is usually measured.

2.6.4 Analysis and consequences of water in fuel

The time it takes for free water to appear in a tank containing fuel with “dissolved” water depends on several factors, including the length of time the mixture has been at rest and the water content. However, there is no specific time frame. Good practice in the aviation industry is to wait approximately 5 to 10 min after refuelling before taking a sample from the tank via the drain ports.

Visual checks for the absence of water in the fuel (samples) are specified in the pre-flight check before the aircraft moves and after refuelling. The purpose of these checks addresses two different issues.

- The check during the pre-flight check is to:
    - ensure that there has been no condensation in the tank or water infiltration if the aircraft has been exposed to rain;
    - verify that if refuelling was carried out at the end of the previous flight without a check, the fuel added was not contaminated.
- The check after refuelling is to ensure, after a rest period, that the fuel added to the tank was not contaminated.

The presence of free water in a fuel tank, although abnormal during flight, will not systematically lead to engine shutdown. This is because the engine’s fuel supply port, unlike the drain port, is not located at the lowest point of the tank. As a result, a certain amount of fuel is considered “unusable,” and this value is specified by the aircraft manufacturer. However, this value may vary more or less depending on the aircraft's attitude during flight (climb, descent, turn, etc.). Depending on the aircraft's movements, even with a volume of free water less than the “unusable” amount, the engine's fuel supply port may be submerged by water.

If the engine is supplied with fuel containing “dissolved” water, this can cause erratic engine operation, while prolonged water intake can lead to an in-flight engine shutdown.

On aircraft equipped with a piston engine, after an in-flight engine shutdown due to a fuel supply failure, the windmilling propeller can restart the engine if it is properly supplied with fuel again. In a helicopter, the rotation of the main rotor does not cause the crankshaft to rotate due to the presence of the freewheel. On the R44, if the fuel supply is restored, the pilot has to make a manual input on the starter to start up the engine.

2.7 Meteorological information

The weather conditions on La Reunion, and more specifically at the accident site, were as follows:

- at Saint Denis airport, easterly wind of 13 kt, CAVOK, temperature 29°C, dew point 19°, QNH 1017 hPa;
- at the accident site, light easterly to north-easterly wind with few clouds to clear skies;
- in the Salazie area, turbulence may have been light to moderate due to rugged terrain, and sea breeze and slope phenomena setting in.

Note: the turbulence reported on the radio by the pilot of F-HLOU, even though it was not confirmed by the helicopter pilot who was also present in the area but at a higher altitude, cannot be ruled out. Given the wind direction, F-HLOU was downwind of the terrain and possibly in an area of turbulence.

2.8 Statements

2.8.1 Pilot of R44 registered F-GZBD (eyewitness to the accident)

The helicopter pilot stated that he had taken off from Saint Pierre Pierrefonds aerodrome at around 08:20 with two passengers for a sightseeing flight. As he approached Le Mazerin bound for the Cirque de Salazie at an altitude of 4,500 ft, he heard the pilot of F-HLOU report that he was passing near Piton d'Enchaing and heading towards the Le Voile de la Mariée waterfalls. He added that he positioned himself about 500 m behind F-HLOU and descended to about 3,600 ft, roughly the same altitude as F-HLOU. He stated that he heard the pilot of F-HLOU call out "Turbulence Turbulence" on the radio, when, according to him, F-HLOU was approximately level with the pass to join the Bras de Cavernes gorges, which lead to the Trou de Fer. Ten seconds later, he heard the pilot of F-HLOU call out "PAN PAN" and again "PAN PAN" a few seconds later while F-HLOU was in a left-hand turn. He added that during the last two radio transmissions, he clearly heard the "LOW NR" warning.

He stated that he saw F-HLOU descend with a flat pitch attitude and noticed the slowing down of the main rotor speed. He added that he saw the helicopter begin to rotate around its yaw axis with the main rotor almost at idle speed before the helicopter suddenly fell and crashed onto the north side of the Mât River near Le Bois de Pomme. He added that the helicopter then slid down the slope before coming to a stop.

He stated that when he flew close to the location where the pilot of F-HLOU had reported turbulence, he did not experience any turbulence. He added that the weather conditions were good, with no clouds or wind in the area. He added that after the accident, he gained altitude to contact the Saint Denis control service and report the accident.

2.8.2 Passenger on R44 registered F-GZBD (eyewitness to the accident)

The passenger specified that he had had sight of the helicopter which he believed was around 600 ft lower than them. He heard the pilot of F-HLOU report turbulence which surprised him as the wind in the sector was very calm. He then heard the pilot of F-HLOU call out "PAN PAN" two separate times and added that he could clearly hear the shrill noise of a continuous warning. He stated that he had had the impression that the main rotor blades slowed down. He confirmed that F-HLOU was heading north-east before carrying out a left-hand U-turn during which he heard the second "PAN PAN" call which was followed by the helicopter entering a near vertical drop and colliding with the ground.

2.8.3 Passenger on first flight with pilot of F-HLOU

The passenger stated that he knew the pilot professionally and had contacted him to arrange a flight for his wife and daughter. He specified that, before the flight, the pilot had given them safety instructions (seat belts, doors, safety positions, etc.) and explained the various phases of the flight. He added that he was seated in the front left seat. He indicated that he had noticed that before take-off, the gauges indicated that one of the tanks was approximately a quarter full and the other tank half full. He specified that the pilot had explained to him that this corresponded to an endurance of 1 hour and 30 minutes with a regulatory reserve of 20 minutes. He added that during the flight, the wind conditions were good with clear skies and no wind.

2.8.4 HELILAGON operator

The operator stated that the R44 was the only helicopter in the company that used 100 LL fuel. The R44 was refuelled from 216 l fuel drums. The drums were ordered in batches of two or three from a supplier, and each batch was accompanied by a fuel quality certificate[12], which also ensured its traceability. The operator specified that the drums were delivered sealed and stored in a metal container locked with a key. He added that the key was given to the pilot leasing the R44 upon his arrival at the heliport and returned at the end of the flights. The R44 pilot himself put the drums into service by removing the supplier's seal. He indicated that the JAPY pump model used did not have a water detector or volumetric meter. He specified that it was the pilot's responsibility to check for water in the fuel by complying with the drain procedures[13] described in the helicopter flight manual. He confirmed that the pilot had put a new drum into service to refuel between the two flights on the day of the accident.

The operator specified that the Le Bois de Pomme[14] area was an identified area where there were several sites which could accommodate an emergency landing (stadium, cultivated fields, road, DZ of a construction company).

3 CONCLUSIONS

The conclusions are solely based on the information which came to the knowledge of the BEA during the investigation.

Scenario

After a first local flight over La Reunion, the pilot refuelled the helicopter from a fuel drum that he had just opened. The JAPY pump used for refuelling did not have a water detector, and the pilot did not drain the tank after refuelling to check for water in the fuel.

At the time of take-off for the second flight, the weather conditions were compatible with a VFR flight. However, a mountain breeze was beginning to develop over the Salazie area, with light to moderate turbulence due to the rugged terrain.

The pilot climbed to cross the Col des Bœufs pass (6,420 ft) and then in descent, crossed the Cirque de Salazie from west to east to reach the Voile de la Mariée waterfalls. The pilot then headed north at an estimated altitude of between 3,000 ft and 3,600 ft, following the terrain, below the ridge line, towards the pass (altitude 2,418 ft) that led to the Bras de Caverne gorge and the Trou de Fer. As he approached the pass, he called out “Turbulence Turbulence” over the radio. The investigation was unable to determine whether the pilot actually encountered turbulence related to local wind conditions.

A few seconds later, i.e. after approximately 15 minutes of flight, the pilot transmitted two “PAN PAN” messages, each accompanied by the “LOW NR” warning indicating a low rotor speed.

[12] The certificate corresponds to the batch number from which the drum originates.
[13] Before the first flight and after each refuelling.
[14] When the pilot of F-HLOU made the “Turbulence Turbulence” call, the area could no longer be reached in autorotation because of the altitude of the flight.

The examination of the wreckage at the accident site and subsequent detailed examinations established that the engine was delivering little or no power prior to the collision with the vegetation, although no mechanical anomalies were found during the examinations.

The results of the analyses of the fuel used during the flight may explain that the turbulence perceived and the failure reported by the pilot were linked to the ingestion of water or contaminated fuel—due to the lack of draining after refuelling—which led to a loss of engine power or even an in-flight shutdown.

It was not possible to determine whether the pilot transmitted these "PAN PAN" messages due to the activation of the "LOW NR" warning or a malfunction of the engine.

The decrease in the main rotor speed and the sudden drop of the helicopter described by witnesses suggest that the pilot did not immediately take the necessary piloting actions to initiate an autorotation (immediately lowering the collective pitch control to stop while pulling on the cyclic stick) in order to maintain or restore the rotor speed to the normal operating range. The main rotor speed then decreased until lift was lost, causing the helicopter to plummet to the ground.

Contributing factors

The following factors may have contributed to the loss of control of the helicopter and the failure to recover it:

- flying at low height overhead steep terrain with dense vegetation, giving the pilot little time and margin to react;
- very probably inappropriate pilot actions in response to a drop in the main rotor speed.

The following factor may have contributed to a possible in-flight engine shutdown or erratic operation due to the ingestion of fuel contaminated with water:

- the pilot not draining the tanks after refuelling, which meant that he was not able to detect the fuel contamination.

The BEA investigations are conducted with the sole objective of improving aviation safety and are not intended to apportion blame or liabilities.