Accident to the Robinson R22 BETA II registered **F-GJYB** on Thursday 11 January 2024 at Cannes-Mandelieu

Time	Around 15:55[1]
Operator	GREEN BEES HELICO[2]
Type of flight	Instruction
Persons on board	Instructor and student pilot
Consequences and damage	Occupants 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.	

Decrease of engine power after take-off, loss of control and collision with surface of sea[3]

1 HISTORY OF THE FLIGHT

Note: the following information is principally based on statements, radiocommunication recordings and images from security cameras.

The student pilot and the instructor were performing an instruction flight from Cannes - Mandelieu airport in order to carry out a reconnaissance of a landing area and manoeuvres in the ground effect. The instructor carried out the walk-around inspection and after starting up the engine at 15:33, they carried out manoeuvres in the ground effect for around ten minutes, overhead the runway.

At 15:54:21, they took off from runway 22 and turned left in compliance with the published departure procedure KOPTER 22[4] (see **Figure 1**).

[1] Except where otherwise indicated, the times in this report are in local time.

[2] Declared Training Organization (DTO) since 24 December 2022 issuing in particular the single engine type rating for the R22 and R44. A request for a conversion into an ATO had been made.

[3] The glossary of abbreviations and acronyms frequently used by the BEA can be found on its web site.

[4] The procedure specifies turning left after take-off so that the aircraft will not cross the extended centreline of runway 17/35 and then flying over reporting point HW at 500 ft (jetty on east side of Béal sheltered harbour).

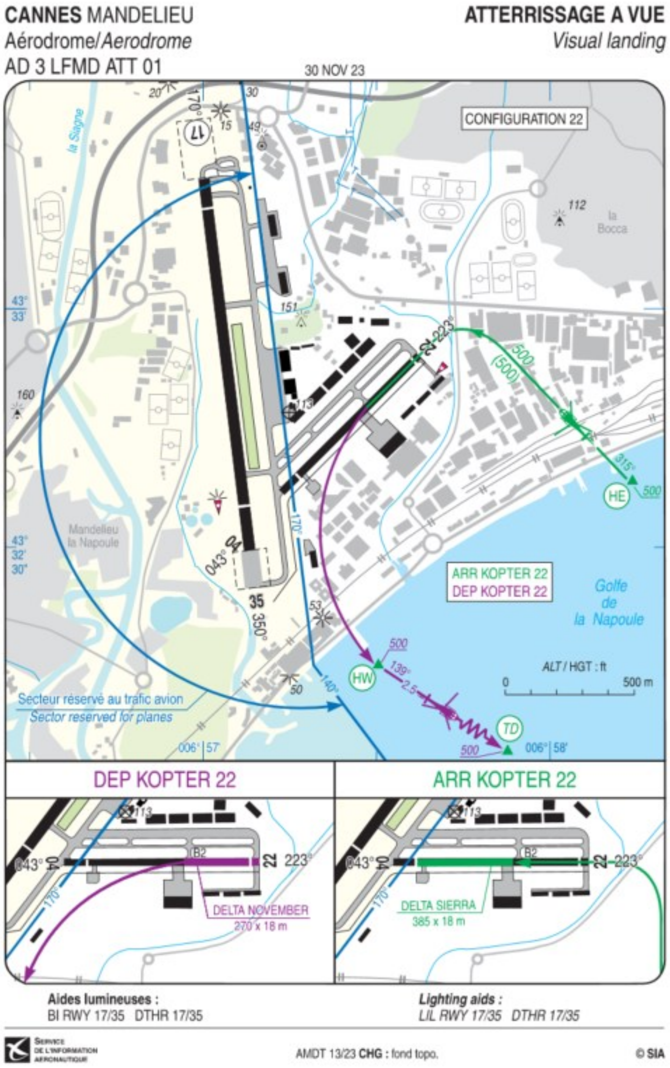

Figure 1: Cannes - Mandelieu VAC chart (source: SIA)

Shortly after turning, the instructor asked the controller for clearance to cross the extended centreline of runway 17/35. The latter replied with the request for her to call back at reporting point WD[5] at a maximum altitude of 2,000 ft. The instructor read this back. The spectrum analysis of these radiocommunications between the instructor and the controller showed that the main rotor rotation speed (NR) was nominal at a value of 102%.

At 15:55:30, the helicopter turned right.

At 15:55:59, the "LOW RPM" aural warning was continuously audible during a two-second transmission without speech from the helicopter[6].

At 15:56:01, the helicopter suddenly lost altitude with a nearly zero horizontal speed and a high vertical speed. Three seconds later, the instructor reported that she had an engine failure. During this last recorded message, the "LOW RPM" aural warning was still audible (see **Figure 2**).

[5] This CTR entry/exit point is situated at 6.5 NM west-south-west of the aerodrome.

[6] The fact that this warning could be heard during the transmission means that the collective pitch lever had not been completely lowered (see paragraph 2.3).

Several witnesses reported a variation in the engine noise or a shutdown before the helicopter fell with a slight nose-down attitude, yawing about itself. Some witnesses indicated that the blades slowed down or stopped turning and then rose upwards.

At 15:56:12, the helicopter collided with the surface of the sea and immediately sunk.

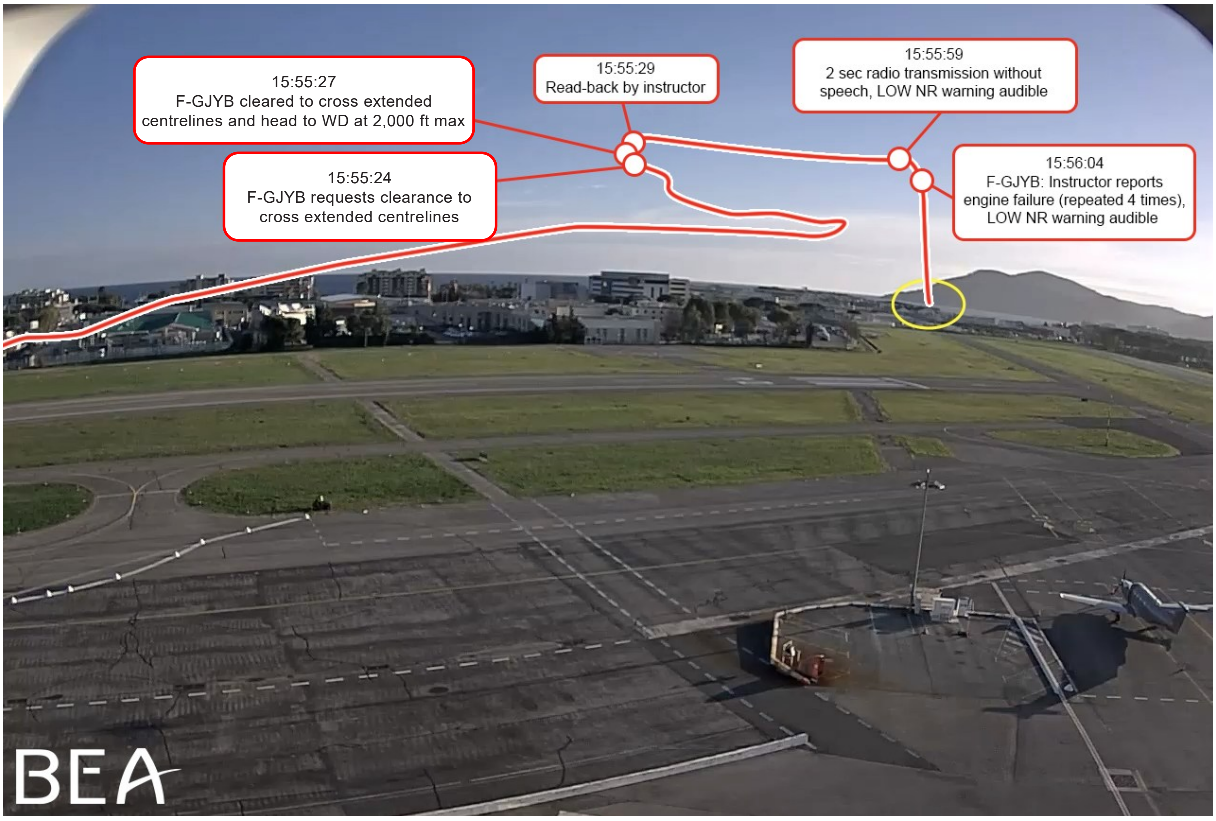

Figure 2: reconstruction of accident flight path

2 ADDITIONAL INFORMATION

2.1 Meteorological information

The ATIS for Cannes-Mandelieu airport indicated from 15:50, wind from 130° of 4 kt, CAVOK, temperature +13°C and dew point +6°C. At the time of take-off, the controller indicated wind from 180° of 8 kt.

According to Météo-France information, there was no turbulence; between 15:00 and 16:00, humidity at surface level was 62% and at an altitude of 1,500 ft, 66%.

2.2 Site and wreckage

The helicopter was resting on its skids at a depth of around 30 m, at around 300 m from the coast and 1.3 km south of the threshold of runway 35 (see **Figure 3**). The tail boom had ruptured at two points and was still attached to the engine mount. The blades were in place as was the tail rotor. The cockpit was partially destroyed.

Figure 3: position of wreckage (source: Geoportail)

The visual examination of the wreckage after it had been raised found that the main damage to the helicopter was the result of the collision with the surface of the water and was consistent with high vertical energy and a nearly zero pitch attitude on impact. The damage observed on the blades of the two rotors was consistent with low energy being provided by the main rotor when it collided with the water.

Figure 4: photograph of wreckage after being raised (source: BEA)

The examinations carried out on the drive system mechanical assembles did not find any particular anomaly.

The examinations of the yaw, cyclic pitch and collective pitch control linkages found that they were probably continuous at the time of the collision with the water. The carburettor heat control was continuous. It was not possible to confirm the continuity of the engine controls (mixture control, throttle control and engine governor).

The other controls were found in the following positions:

- carburettor heat: on (pulled)[7];
- mixture control: full rich;
- fuel valve: ON;
- magnetos: BOTH.

It was not possible to determine the quantity of fuel remaining in the fuel tanks due to the large quantity of sea water present in the tanks. However, an iridescent slick on the water surface and a smell of fuel were observed when the wreckage was raised.

The instrument panel and the engine, and in particular the carburettor, were examined at the BEA:

- the examination of the warning lights determined that the “LOW RPM”, “ALT” and “OIL” lights on the instrument panel were illuminated and that the “GOV” light[8] was probably extinguished at the time of impact. The “GOV” circuit breaker was found tripped; however, it was not possible to determine if it was tripped by the impact or not[9];
- it was not possible to test the carburettor on the test bench due to the damage it had sustained. The visual examination did not find any particularity;
- the test of the temperature probe at the carburettor air intake found that it was not functional. Two breaks in the probe’s internal wire were identified. The visual comparison with a similar probe revealed that this wire was slack and had broken in two places. This damage to the wire was consistent with damage resulting from the impact, without the BEA being able to affirm this. The statements from the pilots who had used the helicopter the morning of the accident flight indicating that the probe had been functional at the time is also consistent with this analysis (see paragraph 2.8);
- after cleaning, the movement of the needle of the carburettor temperature gauge could be checked. The gauge was functional without it being possible to verify its accuracy;
- the engine was partially disassembled and examined. Its outer structure showed no major damage. The internal mechanical assemblies rotated freely. The lubrication system was continuous at the time of impact and its filtering system was free from metal chips.

After raising the wreckage, no object which could have prevented free travel of the controls was found.

[7] A video taken by the divers shows that it was in this position at the bottom of the water, before being raised.
[8] The light illuminates when the battery switch is set to ON and the governor switch (see paragraph 2.3) is set to OFF.
[9] If there is a governor malfunction in flight, then the engine rating must be controlled manually using the twist grip.

2.3 Helicopter information

The helicopter flight manual indicates that, "*The R22 has a light, low-inertia rotor system. Most of the energy required for an autorotation is stored in the forward momentum of the aircraft, not in the rotor*."

Governor
The Lycoming O-360-J2A engine is a de-rated engine[10] equipped with a governor. This system automatically adjusts the throttle control in order to help maintain a constant engine RPM and as a consequence, the rotor RPM in flight. It is active when the engine RPM is between 80% and 117%.

The governor is switched on manually using a toggle switch. It is automatically inhibited when the engine RPM pass below 80%. In this case or if it is intentionally switched off by the pilot, the engine RPM are manually controlled by the pilot using the throttle control.

The governor acting on the throttle control by means of a friction clutch, the pilot can override the governor and directly operate the throttle control to control the engine RPM.

Carburettor heat
When the collective pitch lever is lowered, a mechanical linkage increases the carburettor heat and vice versa. This throttle linkage can be manually inhibited by locking the heat control in the down position (pushed in) by means of a latch.

The temperature in the carburettor is displayed to the pilot by means of a gauge on the instrument panel. The temperature range to be avoided, between -15 °C and +5 °C, is shown by a yellow arc.

Figure 5: carburettor temperature gauge

The maintenance manual recommends that during 100-hour or annual inspections, it is checked that the indicated temperature is more or less identical to the outside air temperature. This check is carried out with the engine shut down. The last check had been carried out during the last 100-hour inspection, in September 2023.

"LOW RPM" warning
When the main rotor RPM is less than 97%, the "LOW RPM" light on the instrument panel lights up and an aural warning sounds. The aural warning is inhibited when the collective pitch lever is lowered to stop (full low pitch).

[10] According to Lycoming, this type of engine improves helicopter performance at high altitudes, its reliability and its service life.

2.4 Carburettor icing phenomenon on the R22

2.4.1 Sensitivity of helicopters to this phenomenon according to Robinson

According to Robinson, carburettor icing can occur, even in high outside air temperatures, according to the rate of humidity. Robinson also indicated that the governor can mask carburettor icing, specifying that the phenomenon "*will not become apparent as a loss of either RPM or manifold pressure. The governor will automatically adjust throttle to maintain constant RPM which will also result in constant manifold pressure*." An uninformed pilot may thus not perceive the formation of carburettor icing (see SN-31 "Governor can mask carb ice").

2.4.2 Publications about carburettor icing

A SIB[11] entitled "carburetor icing prevention" was published by EASA in 2010 in support of a FAA SAIB[12] published in 2009 to inform pilots of aircraft equipped with piston engines of the potential dangers associated with carburettor icing. This document mentions the occurrence of 212 accidents attributed to carburettor icing between 1998 and 2007.

The document entitled "No ice, thank you" available on the FAA site, the conclusions of which Robinson indicates it shares, explains that on de-rated engines like the 0-360-J2A, the butterfly valve inside the carburettor is only partially open when the engine is providing full power and that carburettor icing can occur even during take-off. If this is not corrected as soon as the first symptoms appear (rapid drop in engine RPM), the engine may stop with the rotor stalling at low RPM.

It is specified in the document that to avoid this, the pilot must open the throttle, lower the collective pitch lever and pull full carburettor heat. If the pilot merely lowers the collective pitch lever, the engine may stop: the carburettor heat assist system may not be sufficient as it only applies carburettor heat when the pilot lowers the collective pitch lever.

The document also indicates that in certain moist atmospheric conditions, when the relative humidity is more than 50% and the temperature is between −6 °C and +32 °C, ice may form in the induction system, even in summer weather. However, this phenomenon is most likely to occur in the -1°C and +15°C temperature range.

Furthermore, it is indicated that pilots must check that the carburettor air temperature indication is accurate (this can only be done when the engine is cold) during the ground checks. According to inspector pilots from the DSAC PN/EPN section, the sensation of heat in the cockpit caused by the thermal radiation from the helicopter's bubble canopy can also reduce pilots' vigilance regarding monitoring the temperature inside the carburettor.

The airport camera images showed that there was an approximately 13-minute interval between the main rotor coming to a complete stop at the end of the previous flight and the start of blade rotation at the beginning of the accident flight. When the instructor carried out the walk-around inspection, the engine had therefore most certainly not cooled down completely. The carburettor temperature indication may have been higher than the real outside air temperature and the instructor was most certainly not able to do the check.

[11] Safety Information Bulletin.

[12] Special Airworthiness Information Bulletin.

2.4.3 Manufacturer's flight manual and operator's documents

The helicopter flight manual recommends testing the carburettor heat after starting up the engine with an engine rating between 70 and 75 % (RPM), by checking on the gauge, that the carburettor temperature increases after pulling the control and decreases after pushing it back in.

According to the flight manual, when the conditions are conducive to carburettor icing, the pilot must use carburettor heat (manual control whatever the position of the collective pitch lever) as follows:

- at least during the run-up to preheat the induction system;
- as required during take-off, climb and cruise to keep carburettor temperature indication out of the yellow arc;
- at least when the manifold pressure is below 18 in.

All the ROBINSON SAFETY NOTICES were in Part 10 – SAFETY TIPS of the F-GYJB flight manual[13], and in particular:

- SN-10 published in October 1982 "Fatal accidents caused by Low RPM rotor stall";
- SN-25 published in December 1986 "Carburator Ice";
- SN-27 published in December 1987 "Surprise Throttle chops can be deadly";
- SN-20 published in June 1994 "Beware of demonstration or initial training flights";
- SN-31 published in December 1996 "Governor can mask carb ice".

2.5 Management of an autorotation in the R22

The maximum glide speed of the R22 is around 75 kt and the maximum lift-to-drag ratio is close to 4 (-1,500 ft/Nm) with a main rotor RPM of 90%.

In the event of an engine failure, Robinson indicates that the pilot must put the helicopter into autorotation by immediately lowering the collective pitch lever to maintain the rotor RPM while opening the butterfly throttle valve as, should the main rotor RPM decrease below 80%, the rotor will stall.

The "LOW RPM" light and aural warning are simultaneously activated below 97% RPM and stop when the collective pitch lever is lowered to stop. The pilot must then descend with an indicated airspeed of around 65 kt once in the autorotation.

2.6 Persons on board information

2.6.1 Student pilot

The 27-year-old student pilot did not have any aviation qualifications. He had been following training since 14 September 2023 with a view to obtaining the PPL(H) and then the CPL(H). He had carried out 17 dual control flights, including 4 flights with the instructor and had totalled around 18 flight hours (all on type) including 11 hours in the previous 3 months. The Nominated Person Flight Operations (NPFO) indicated that he had been progressing normally and that autorotations with the reflex actions to manage failures had been covered in two sessions in which his hands were resting on the controls to follow the instructor's actions.

[13] It is indicated in the R22 OSD TASE, that it is mandatory to carry out a detailed study of all the Safety Notices and Safety Tips contained in the flight manual.

2.6.2 Instructor

The 35-year-old instructor held a CPL(H) licence obtained in November 2022 and a restricted[14] FI(H) rating from 17 April 2023. During her FI(H) training she had carried out around thirty autorotations. She had obtained the initial R22 TR in June 2021[15]. According to her electronic logbook, she had logged approximately 300 flight hours including 235 hours on type, and approximately 12 hours including 10 hours on type in the previous three months. She had been an instructor with the DTO since June 2023. She had provided a total of 47 instruction hours, including around 25 hours on the R22 and had supervised 12 solo flights.

The DTO manager indicated that she had been recruited by the DTO on 13 June 2023 after carrying out an assessment flight. He had not yet authorized her to carry out autorotation and failure exercises with student pilots. The DTO NPFO added that she had informed him of her wish to improve her autorotations. She had not yet done so with him or the DTO[16] manager. According to her electronic logbook, she had not carried out any autorotation in instruction since her assessment flight and had not practised any while flying alone since 28 June 2023, the date of her last flight on the R22 as pilot-in-command.

The results of the ENT examination that she had passed on 11 March 2021 to obtain her medical fitness certificate were in the class 1 requirements.

Just before leaving for the flight, the instructor had told the pilot of the previous flight that she was a little unwell (see paragraph 2.8). This statement was corroborated by the results of the toxicological analysis of the blood samples taken after the accident, which showed in particular, traces of paracetamol and steroidal anti-inflammatory drugs.

2.6.3 Survival aspects

The instructor and student pilot were fatally injured when the helicopter collided with the surface of the water; the collision left no chance of survival. The autopsies were not able to determine who was flying at the time of the accident. No sign indicating a possible malaise was observed. No traces of substances that could have impaired the performance of the student pilot or instructor were found.

The DTO's operations manual did not contain any specific instructions regarding the carrying of life jackets. It simply stated that in accordance with applicable regulations, the pilot-in-command must ensure that the helicopter is airworthy for the planned flight. There was no lifejacket on board F-GJYB. The regulations applicable at the time of the accident for this flight which would be passing over water on take-off, (requirement NCO.IDE.H.175 - Flight over water), required them to be worn or stowed in a location easily accessible from the seat. The GREEN BEES HELICO manager had considered it was not necessary to equip the R22s with life jackets, as they would not have been accessible under the seats.

[14] To lift the restriction, the pilot must have carried out 100 instruction hours in flight on helicopters and supervised at least 25 student pilot solo flight exercises. The privilege restriction of her FI(H) rating had not been lifted and she was still being supervised by the NPFO.
[15] The content of the specific training imposed since 1999 in France by the DGAC for instructors flying on the R22 and R44, commonly called "Robinson safety course", was integrated in 2015 into the OSD of the R22 TR.
[16] The DTO operations manual indicates that an instructor can ask the training manager for periodic training or the latter can propose training to an instructor based on identified needs, notably failure and complete autorotation exercises.

Since the accident, requirement NCO.IDE.H.175 has been modified. The following points are indicated:

NCO.IDE.H.175 — Flight over water

a. "*Helicopters shall be equipped with a life-jacket for each person on board or equivalent individual flotation device for each person on board younger than 24 months, which shall be worn or stowed in a position that is readily accessible from the seat or berth of the person for whose use it is provided, when*:

   (...)

   4. *taking off or landing at an aerodrome/operating site where the take-off or approach path is over water.*

   (...)

d. *The pilot-in-command shall determine the risks to survival of the occupants of the helicopter in the event of a ditching, when deciding if the life-jackets required in (a) shall be worn by all occupants*."

According to the DSAC, this modification is a means of insisting on questioning whether a life jacket should be worn.

2.7 Influence of ANC/ANR[17] headset on reaction time

The student pilot was wearing a headset without a noise reduction system and the instructor was wearing a BOSE A20 ANC/ANR headset. Several safety investigations carried out in France and abroad have questioned the possible contribution of this type of headset to the perception of background noise and, in the case of F-GJYB, to the perception of a reduction in rotor RPM and as a consequence, to the instructor's reaction.

According to the headset manufacturer, the BOSE A20 model meets European requirements ETSO-C139 which refer to industrial standard RTCA DO-214A. This document specifies that the use of a noise reduction headset must be adapted to the background noise of the cockpit in order not to impair the perception of important aural signals.

It also indicates that for the majority of passive or active noise reduction headsets, such as the BOSE A20 model, the attenuation is similar for the background noise and for alert signals in each frequency band. The signal-to-noise ratio is therefore not altered, and, as a first approximation, a signal audible without a headset remains audible with a headset, provided its perceived level remains sufficient. However, caution is advised with headsets where the reduction depends on background noise (for example, an ANR headset with active adaptation).

Several autorotations were carried out on an R22 by an instructor accompanied by a BEA investigator and helicopter pilot. They wore in succession, a non-ANR David Clark headset and then an ANR BOSE A20 headset. In both configurations, the aural perception of the decrease in rotor RPM and the "LOW NR" warning were considered satisfactory, with no impression of the sound being attenuated or masked. This assessment is also shared by the inspector pilots of the DSAC PN/EPN section.

However, only specific tests carried out in a controlled environment would make it possible to generalise this initial assessment, particularly with respect to a possible influence on the pilots' reaction time.

[17] Active Noise Cancellation / Active Noise Reduction.

2.8 Statements

The instructor's student pilots indicated that she was aware of the risk of carburettor icing and attentive to the carburettor temperature indications. One of them explained that on several occasions he had wanted to lower the collective pitch lever to start descending without having pulled the carburettor heat control, and that each time she had prevented him from doing so by blocking the collective pitch control. Another student explained that she regularly had him check the temperature of the carburettor.

Several student pilots who had flown in the morning indicated that they had tested the "LOW RPM" aural warning and light before entering hover or in flight, during autorotation exercises and that they had operated normally.

Two student pilots who had flown between 10:00 and 13:30 on F-GYJB explained that they had had to use the carburettor heat in flight to prevent the needle of the carburettor temperature gauge entering the yellow arc. According to the DTO manager who had carried out the dual-control flight with them, the needle of the gauge was in the yellow arc as soon as they were in hover and stayed at the edge of the arc even after half-pulling the carburettor heat control.

The pilot of the previous flight indicated that he had not observed anything abnormal even at the end of his flight when he carried out an additional walk-around inspection. He stated that he had half-filled the main and auxiliary fuel tanks by adding 40 litres of fuel after the flight. He added that he had talked with the instructor who had told him that she was feeling a little unwell.

3 CONCLUSIONS

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

Scenario

The investigation was not able to determine who had the controls and what actions were carried out on the controls, and in particular on the collective pitch lever and the carburettor heat control, by the instructor or the student pilot.

A few minutes after taking off, the helicopter experienced a substantial reduction in power. The investigation was not able to determine with certitude, what caused this. However, given the temperature and humidity conditions which existed at the time of the accident, the risk of severe carburettor icing was present. If hypothetically such a phenomenon occurred, associated with possible prior inadequate management of the carburettor heat control, it is possible that the carburettor air duct became blocked, accompanied by a loss of engine power.

The instructor's perception of icing may have been delayed by the governor temporarily maintaining the engine RPM. When the governor was no longer able to compensate for the decrease in engine RPM, and in the absence of an immediate autorotation, the rotor RPM decreased and then the helicopter fell nearly vertically until collision with the surface of the water.

It was not possible to establish the reason why the collective pitch lever had not been completely lowered although the "LOW RPM" aural warning was sounding.

Contributing factor

The instructor's absence of recent autorotation practice, in relation to her total experience, may have contributed to a possible inappropriate reaction to the sudden decrease in main rotor RPM.

Safety messages

Information regarding carburettor icing risk on the R22 (see paragraph 0)
The circumstances of this accident, as well as publications from Robinson, EASA and the FAA, serve as a reminder that severe carburettor icing on the R22 can occur even when there is a clear sky and the temperatures are well above freezing.

Robinson recommends, if in doubt, using the carburettor heat to maintain the air temperature in the carburettor outside the yellow arc of the gauge and applying full carburettor heat when the manifold pressure is below 18 in. It is also recommended to verify the accuracy of the carburettor air temperature gauge with a cold engine during ground checks by comparing the temperature displayed with the outside air temperature.

Information regarding the risk associated with a loss of power
During the investigation, the BEA spoke with a DSAC inspector pilot who indicated that he had observed that in all the engine failure simulations on the R22 conducted during tests with FI(H)s, everyone sought to understand the cause of the problem and resolve it before reducing the collective pitch lever.

Robinson has published several documents related to managing engine power loss and the appropriate responses in case of a loss of rotor RPM (see paragraph 2.4.2).

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