Transportation Safety Board of Canada

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AVIATION INVESTIGATION REPORT
A08A0007

HARD LANDING—POWER RECOVERY AUTOROTATION

UNIVERSAL HELICOPTERS NEWFOUNDLAND LIMITED
EUROCOPTER AS 350 BA ASTAR (HELICOPTER), C-FHHH
MOUNT PEARL, NEWFOUNDLAND AND LABRADOR
10 JANUARY 2008

Canada

Aviation Investigation Report

Hard Landing – Power Recovery Autorotation

Universal Helicopters Newfoundland Limited
Eurocopter AS 350 BA Astar (Helicopter), C-FHHH
Mount Pearl, Newfoundland and Labrador
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Report Number A08A0007

Summary

The Eurocopter AS 350 BA helicopter (registration C-FHHH, serial number 1421), with two pilots onboard, departed the company's base just south of the St. John's International Airport, Newfoundland and Labrador, to conduct annual recurrent training. Upon arriving in the training area at 1433 Newfoundland and Labrador standard time at approximately 600 feet above ground level, the training pilot retarded the fuel flow control lever to simulate an engine failure. The pilot commenced an autorotation. Nearing the end of the exercise, the fuel flow control lever was advanced to restore power to the engine with a view to executing an overshoot. The engine (a Turbomeca Arriel 1B, serial number 4193) did not spool up as expected. The pilot continued the autorotation, contacting the ground at a high rate of descent. Both pilots sustained serious injuries; the helicopter was destroyed.

Ce rapport est également disponible en français.

Other Factual Information

History of the Flight

The accident flight consisted of conducting exercises pertinent to annual recurrent training on the AS 350. This included an unannounced simulated engine failure exercise enroute to or from the training area, which was briefed prior to flight.

At 1428 Newfoundland and Labrador standard time [1], the helicopter took off and climbed to 1200 feet above sea level (asl) on a south-westerly heading. At 1433, while approaching a bog at approximately 600 feet above ground level (agl), the training pilot retarded the fuel flow control lever (FFCL) with a view to reducing engine power to 70 per cent engine speed (Ng) to simulate the engine failure (see Appendix A). Collective pitch was lowered and the helicopter flown into the wind (wind speed was estimated at 25 knots). It was not possible to confirm the Ng setting during the autorotation exercise. The warning horn sounded [2] and continued to do so intermittently throughout the autorotation exercise.

As the helicopter descended through approximately 150 feet agl, the training pilot advanced the FFCL [3] to the flight detent position and advised the pilot. This action cued the pilot to apply collective pitch and execute an overshoot. Rotor rpm (NR) decreased. The training pilot confirmed that the FFCL was in the flight detent position. The helicopter overshot the bog and was above a wooded area facing a power line and a congested highway. With a view to returning toward the bog, a steep left turn to downwind was executed and collective pitch was increased to extend the glide. The helicopter struck the ground with a high vertical rate of descent in a nose-down, right-skid-low attitude.

After the crash, communication with the St. John's airport control tower was unsuccessful. A cell phone was used to notify the company of the aircraft's location. The company advised the tower and dispatched a helicopter to the site. Fire rescue services arrived on scene within fifteen minutes. The company helicopter transported the pilots to a hospital. The emergency locator transmitter (ELT) activated on impact.

From the data extracted from the helicopter's global positioning system (GPS), airspeed at the top of the autorotation was approximately 100 knots. At the time collective pitch was increased to execute the go-around, the airspeed was 90 knots. The recommended speed for executing autorotations is 65 knots, which gives the best rate of descent speed for the AS 350. Speeds higher than that induce higher rates of descent.

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1 All times are Newfoundland and Labrador standard time (Coordinated Universal Time minus 3.5 hours).

2 The horn sounds at a rotor speed of 360 rpm and below to signal rotor speed decay.

3 The control quadrant of the fuel flow control lever is located on the floor between the front seats, to the left of the collective lever.

Pilot Information

Both pilots held valid commercial pilot licenses and type ratings. Their last pilot proficiency checks were conducted on the Bell 206 in January 2007. Their last recurrent training sessions on the AS 350 were conducted during the same month.

The training pilot, also the company chief pilot, had 10 700 hours of total time with 750 hours on type. The pilot receiving training had 10 270 hours with 475 hours on type. He held the position of company safety officer since 2003. His recurrent ground training was completed the day before the accident.

Save for the wind, which was reported at St. John's airport as 270° magnetic (M) at 23 knots, gusting to 29 knots, weather was not a factor.

Wreckage

The autorotation exercise was initiated over a snow–covered wet spongy bog, sparsely covered with short spruce trees. After initial impact, the helicopter continued forward approximately two feet, shearing the skids from the cross tubes and twisting the front cross tube back parallel with the longitudinal axis. The cabin floor buckled two feet upwards between the aft wall of the cabin and the crew seats. The two cantilever mainframes were completely severed aft of the crew seats. The two composite crew seats exhibited cracking and deformation in both the vertical and lateral planes. The right-side crew seat had separated from its floor mounting.

The tail boom was partly severed, skewed to the right, and lying on its right side. The short tail rotor drive shaft separated from the long tail rotor drive shaft. Rotation marks found on the drive shaft cover indicated rotation at the time of impact. Damage to the starflex main rotor hub and the three main rotor blades was consistent with low rotor speed, indicating a low-energy state at the time of impact. Further examination of the helicopter confirmed that there were no pre-impact anomalies.

Examination of the engine and its components at the Turbomeca facilities in Mirabel, Quebec, revealed no discrepancies. This examination was attended by a TSB investigator. The helicopter instruments and the caution advisory panel indicate that the engine was operating at the time of impact. It was not possible, however, to determine the actual power being produced by the engine. There was no evidence of turbine or compressor wheel rub or thermal distress. No faults were found with the fuel control unit (FCU). The hard landing damaged the freewheeling unit shaft to the extent of exceeding the run-out limits.

Records indicate that the helicopter was maintained in accordance with existing regulations.

Injuries

Both pilots suffered severe back injuries due to the hard landing. Neither pilot was wearing his shoulder harness. Many Universal Helicopters Newfoundland Limited (UHNL) pilots do not wear shoulder harnesses while conducting certain operations, such as long lining, as they restrict upper body movement. The training pilot was not in the habit of wearing his shoulder harness, nor was he aware of the requirement [4] to do so.

The training pilot was not wearing a helmet [5]. He sustained severe facial and head injuries. The other pilot was wearing a helmet and did not incur head injuries; scarring on his helmet indicates contact with the helicopter structure during impact sequence (See Photo 1).

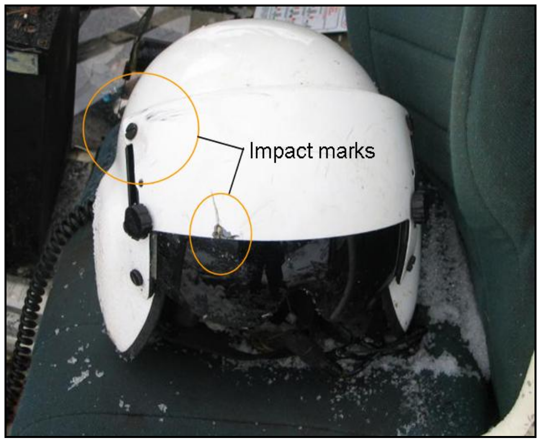

Photo 1. Pilot's helmet

Eurocopter AS 350 Autorotation Procedures

The procedures for conducting practice autorotations on the AS 350 depend on the model and are specified in the appropriate rotorcraft flight manual (RFM). The accident aircraft was equipped with a FFCL on which there is no idle stop position (See Figure 1). More recent models of the AS 350 are equipped with a twist grip that incorporates an idle stop position.

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4 Subsections 101.01 (1), 605.27 (1), and 605.27 (3) of the *Canadian Aviation Regulations* (CARs).

5 The use of helmets is not required by regulation.

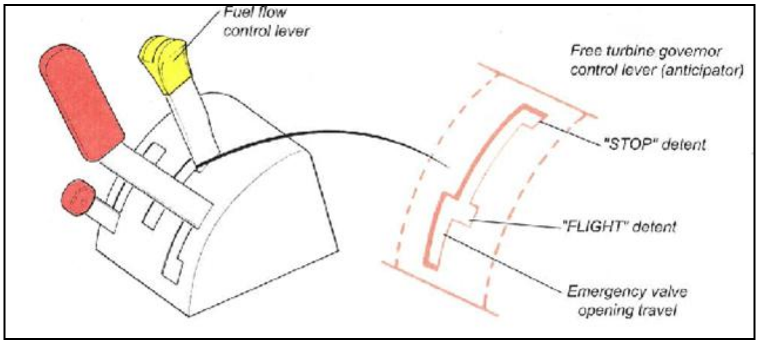

Figure 1. AS 350 BA Fuel Flow Control Lever

For FFCL-equipped models, the AS 350 RFM does not approve engine power reductions in flight because there is a risk of retarding the lever beyond the self-sustaining power regime.

Nevertheless, the autorotation landing training procedure states:

- Reduce collective pitch to establish autorotation configuration;
- Monitor and control rotor rpm;
- During final approach, shut down the engine, <u>or reduce power</u>, maintaining the Ng above 67 per cent;
- After touchdown, still at low collective pitch, apply the normal starting procedure.

The AS 350 manual espouses a practice autorotation procedure that results in a landing with either zero engine power or partial power (i.e.: 67 per cent Ng). If engine power is contemplated for recovery, as in an overshoot, the FFCL should not be retarded from its normal flight position.

Two years prior to the accident, a Eurocopter training pilot gave a course to the company's chief pilot and training pilots. The autorotation procedure on the FFCL-equipped AS 350 was conducted in accordance with the RFM described above. When a safe autorotation landing was assured, the Eurocopter training pilot shut down the engine or reduced power while in the flare at a height of 20 to 25 feet. Power recovery autorotation exercises consisted of lowering the collective without reducing engine power. Reduction of engine power in flight and subsequent re-application of power to accomplish a recovery autorotation was neither discussed nor demonstrated.

Universal Helicopters Newfoundland Limited Autorotation Procedures

Autorotation training procedures contained in the *UHNL Operations Manual* are generic in nature and do not relate to any one type of aircraft. The manual states that prior to executing an autorotation, pilots must, among other things, ensure that the height is sufficient for entry and recovery and that the area is suitable in the event of an actual engine failure. A minimum altitude at which a pilot shall initiate power recovery is not specified. However, when conducting power recovery autorotations for maintenance test flight purposes, the company set 500 feet agl as the minimum altitude at which power must be applied [6].

At UHNL, annual flight training incorporates a simulated engine failure exercise. As the areas over which the exercise is accomplished may not always be suitable for a running landing, a power recovery procedure is espoused. Company pilots believed the procedure published in the manufacturer's flight manual did not preclude the use of the FFCL to do so. Moreover, UHNL decided not to adopt the procedure used by the Eurocopter training pilot for two reasons. First, it was uncomfortable reducing power in the flare close to the ground. Second, it believed that a reduction in engine power, which disengages the engine from the drive train, was necessary to accurately reproduce engine-out flight performance. Instead of using Eurocopter's autorotation procedure, UHNL adapted the procedure used on the Bell 206 JetRanger.

The JetRanger is equipped with a twist grip-type fuel control with an idle stop detent. The autorotation procedure calls for twisting the throttle to the idle detent and lowering collective. Depending on the circumstances, an autorotation would result in a landing with the throttle in the idle detent, a landing with partial throttle applied, or an overshoot with full throttle. This procedure is also described in the *Transport Canada Helicopter Flight Training Manual* (TP 9982).

It speaks to an autorotation recovery procedure for twist grip type throttle equipped helicopters only and calls for rolling it to idle. It is completely silent on other types of fuel control/throttle systems.

While UHNL training pilots did not experience incidents related to the application of this procedure, pilots from other companies have, which resulted in uncontrolled engine spool down and inadvertent engine shutdown.

After maintenance is performed on flight controls, a flight test is required. This is to confirm, among other things, that rotor speed remains within a specific range during autorotation.

The accident aircraft's autorotation NR was checked in the fall of 2007. Though the flight parameters were not recorded—UHNL does not require it—the NR was not reported as being low. Calculations done in accordance with the RFM [7] indicate that the NR should stabilize around 405 rpm ± 5 rpm during an autorotation with an indicated airspeed of 65 knots. It was determined, however, that during the accident flight, the NR stabilized at around 360 rpm. Furthermore, the autorotation NR for this helicopter was noticed to be in the low range, at approximately 360 rpm, during previous training flights.

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6 *UNHL Operations Manual*, chapter 5, section 5.4, Power Recovery Autorotations

7 Section 8 - Servicing check of low-pitch stop adjustment

Analysis

By the time the pilots realized that engine power was not recovering, they overshot the bog. They then executed a 180-degree steep turn in an attempt to return to the bog for a forced landing, which exposed the helicopter to a 25-knot tailwind landing. The autorotation was flown at a higher-than-recommended airspeed which, coupled with the steep turn, increased the rate of descent. This high rate of descent could not be arrested prior to contact with the ground because of the low-energy state of the main rotor.

During the autorotation descent, the warning horn sounded intermittently, indicating an NR at or below 360 rpm, when it should have been approximately 405 rpm. This low rotor speed was due to:

- rotor speed flying controls being out of adjustment;
- the application of collective pitch before confirming that engine power was restored to the flight range; and
- the application of collective pitch to extend the range to reach the bog during the final phase of the autorotation.

Although examination of the engine revealed no anomalies, the NR decreased when the pilot applied collective pitch to execute a go-around. It could not be determined with certainty why the engine did not respond when the FFCL was advanced to the flight detent; however, it was established that the engine was running at the time of impact.

Three scenarios provide plausible explanations for the lack of power to the rotor: lack of crew coordination, low setting of the FFCL, and an unidentified malfunction.

Theoretically, the helicopter's height and speed were sufficient to successfully complete an autorotation to a suitable landing surface. However, the choice of terrain and the altitude at which the power recovery exercise was initiated demanded good crew coordination. The FFCL and the collective lever had to be operated independently, in a precise sequence, and in a timely manner [8]. At about 160 feet agl, the pilot initiated a go-around [9]. At this time, the helicopter had a sink rate of approximately 2300 feet per minute. It is possible that the rapidly approaching ground hastened the actions of the crew, resulting in the increase of collective pitch before the FFCL reached the flight detent. In this situation, the power demand (increasing pitch angle and decreasing NR) may have exceeded the capacity of the engine to re-establish the NR within its limits.

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8 The FFCL had to be placed in the flight detent to ensure engine spool up prior to collective pitch application and at an altitude that would allow sufficient time to stop the vertical momentum of the helicopter.

9 At 1433:30, the sink rate decreased from 2340 feet per minute to 360 feet per minute (see Annex A).

While in cruise, the training pilot retarded the FFCL with the intent of stabilizing the Ng at 70 per cent. Given that there is no flight idle detent on the FFCL quadrant, the training pilot had to monitor the Ng gauge until the target value was reached. Following the reduction of engine power, while attempting to evaluate the actions of the pilot, the training pilot may not have been monitoring the Ng gauge closely enough. Because there is no physical stop between the flight detent and the stop detent (see Figure 1), it is possible that the FFCL was inadvertently set at or accidently moved to a position that caused the engine to spool down.

It is possible that an unidentified mechanical problem contributed to the decrease of NR after the positioning of the FFCL in the flight detent and the subsequent increase in collective pitch. However, an examination of the engine and pertinent aircraft systems did not reveal any anomalies, nor were any observed or noted on previous flights.

The student pilot had to demonstrate adequate knowledge of the engine failure procedure and ability to conduct an autorotation. To this end, in accordance with UHNL normal practice, the training pilot reduced engine power to 70 per cent Ng while the helicopter was approaching the training area. All UHNL training pilots had used this procedure for the previous two years without incident.

The RFM warning about reducing the FFCL in flight is not included in its section on autorotations. The lack of explicit instructions prohibiting the use of FFCL for power recovery autorotations may have led the UHNL training pilots to assume that the FFCL can be used. It seems UHNL training pilots adapted the power recovery autorotation procedure for a twist grip throttle/collective, which allows for throttle use during power recovery.

The terrain below the helicopter was suitable in the event of an actual engine failure because it was virtually free of obstacles. However, in view of its mushy and uneven surface, the area was not suitable to conduct a run-on landing and it may have made an upright landing unlikely. Therefore, a firmer and more level surface would have been preferable to conduct the power recovery exercise in the event of an inadvertent engine failure.

Neither pilot was wearing shoulder harnesses, which likely contributed to the severity of their injuries. It was common practice for company pilots to not use them for certain operations. The chief pilot never wore his shoulder harnesses and was not aware that it was mandatory to do so. The company operations manual does not explicitly state that pilots should wear their shoulder harnesses. The fact that the chief pilot did not wear his may have influenced others towards non-compliance.

The pilot wearing his helmet did not receive head or facial injuries. The training pilot was not wearing a helmet and incurred severe facial injuries; the use of a helmet would likely have reduced the severity of his injuries.

The following TSB Engineering Laboratory Reports were completed:

LP 012/2008 – GPS Download

LP 014/2008 – Instrument and Light Examination

These reports are available from the Transportation Safety Board of Canada upon request.

Findings as to Causes and Contributing Factors

1. The lack of explicit instructions prohibiting power recovery autorotations in the AS 350 rotorcraft flight manual (RFM) resulted in the Universal Helicopters Newfoundland Limited training pilots adapting a practice of fuel flow control lever (FFCL) operation that was contrary to the manufacturer's intent.

2. The training pilot retarded the FFCL with the intention of executing a power recovery autorotation. The engine did not respond as anticipated when the FFCL was advanced for the overshoot and a high rate of descent ensued.

3. The autorotation was flown at a higher-than-recommended airspeed which, coupled with the steep turn, increased the rate of descent. This high rate of descent could not be arrested prior to contact with the ground because of the low-energy state of the main rotor.

4. Both pilots suffered severe back injuries due to the hard landing. Neither pilot was wearing a shoulder harness; this likely contributed to the severity of their injuries.

5. The training pilot suffered severe facial injuries. He was not wearing a helmet; this likely contributed to the severity of his injuries.

Finding as to Risk

1. Practice autorotations over unsuitable terrain could result in injury and aircraft damage should a forced landing be required.

Other Finding

1. While the rotor rpm (NR) was within the autorotation range, it was not set at its optimum setting, reducing the energy state of the rotor.

Safety Action Taken

Universal Helicopters Newfoundland Limited has issued the following safety memos:

- Shoulder harness—addressed to all pilots, advising that the use of the shoulder harness is mandatory.

- Autorotation in AS 350-series helicopters—addressed to all pilots, advising them that unless intending to do a full-on practice autorotation, manipulation of the throttle in flight is not authorized. This includes power recoveries and surprise autorotations.

- Autorotation rpm verification—addressed to all pilots and maintenance engineers, instructing them to record all required parameters, such as weight, altitude, temperature, speed, and NR [rotor rpm], anytime autorotation rpm verification flights have been conducted.

The company has implemented a policy of cost sharing and interest-free loans to facilitate flight helmet purchase by the company's pilots. Many pilots have taken advantage of this offer and more pilots are now wearing helmets during flight operations.

Eurocopter has developed a proposed supplement for the AS 350 rotorcraft flight manual (RFM) that deals with engine emergencies training procedures. The proposal provides explicit instructions on the procedure to be followed for practice autorotations, for both fuel flow control lever (FFCL) and twist grip engine controls. Regulatory approval is pending.

This report concludes the Transportation Safety Board's investigation into this occurrence. Consequently, the Board authorized the release of this report on 17 March 2009.

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Appendix A – GPS track of the power recovery autorotation