Transportation Safety Board of Canada
Bureau de la sécurité des transports du Canada

AVIATION INVESTIGATION REPORT
A04C0190

COLLISION WITH TERRAIN

CANADIAN HELICOPTERS LIMITED
BELL 212 C-GMOH
SHEPHERD BAY, NUNAVUT
30 OCTOBER 2004

Canada

Aviation Investigation Report

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Summary

The Canadian Helicopters Limited Bell 212 helicopter (registration C-GMOH, serial number 31133) with two pilots and three passengers on board, departed from the radar facility at Shepherd Bay, Nunavut, at approximately 1110 mountain daylight time on a day, defence visual flight rules flight to another radar facility at Gjoa Haven, Nunavut. During take off from Shepherd Bay, the helicopter descended and crashed, in a nose-low, left-banked attitude, into the snow-covered terrain about 250 metres from the departure helicopter pad. The captain and the three passengers were seriously injured, and the first officer died at impact. The survivors were able to return to the facility and alert search and rescue. The helicopter sustained substantial damage; there was no fire.

Ce rapport est également disponible en français.

Other Factual Information

Canadian Helicopters Limited is headquartered in Les Cedres, Quebec, and operates a large fleet of helicopters from several bases throughout Canada. Its Bell 212 helicopters are certified for air taxi operations under Canadian Aviation Regulation (CAR) 703. Helicopter C-GMOH was based in Cambridge Bay, Nunavut, and was certified for CAR 703 operations under both visual (VFR) and instrument flight rules (IFR). The helicopter was used to move personnel and maintenance equipment at North Warning System (NWS) sites.

Accident Site Description

The NWS complex at Shepherd Bay is not staffed, but has a well-equipped barracks with private sleeping accommodations for deployed crews. The complex is built on a small ridge, and an abandoned gravel runway is located to the southeast of the ridge. A hangar is located near the runway, approximately ½ mile from the helicopter pad, and the hangar can be seen from the NWS site. The helicopter pad is at the west side of the complex at the edge of the ridge, with structures nearby on each side and to the rear of the pad. The pad is monitored by a video security system, and a video recording of the departure was obtained. The elevation of the pad is 135 feet above sea level (asl). The pad is marked by edge lighting, which was illuminated during the departure of C-GMOH. The pad slopes down gently in the direction of the departure, with the ridge then dropping rapidly about 60 feet from the edge of the pad to the surrounding terrain. The terrain surrounding the ridge line and the complex is flat and featureless except for the hangar to the southeast side. At the time of the accident, the terrain was completely snow covered and there was no visible vegetation or rock.

Weather

The weather at the time of the accident was reported by the Shepherd Bay automated weather observation station at 1111 mountain daylight time[1] as follows: visibility one statute mile, temperature -18° C, wind 200° True at seven knots, and altimeter 29.65. Prior to departure, the crew were able to clearly observe the hangar about ½ mile from the facility. The security video revealed an obscured sky condition with no discernable horizon. Structures near the helicopter pad could be seen clearly; there were no shadows. Although there was no falling snow, loose snow obscured the camera's view after the helicopter climbed from its initial hover.

History of Flight

On the day of the accident, the crew of C-GMOH were on the fourth day of a deployment to the NWS site at Shepherd Bay with three passengers and their equipment. Initially, a departure was planned at 0800 to another NWS site at Simpson Lake, and the crew arose about 0600. Weather information was obtained from Arctic Radio and a defence visual flight rules flight plan filed; however, the flight to Simpson Lake was later cancelled because of weather. The NWS site at Gjoa Haven was then selected as the destination, and the flight plan was amended. Because of

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[1] All times are mountain daylight time (Coordinated Universal Time minus six hours).

weather concerns at Gjoa Haven, the captain had the helicopter's fuel topped up to about 2400 pounds to permit a weather diversion to Cambridge Bay, if necessary.
Communications problems at Shepherd Bay delayed the departure until approximately 1100.

Shortly before 1100, the helicopter was loaded and prepared for flight. The first officer occupied the right seat as the pilot flying (PF) and the captain performed the duties of the pilot non-flying (PNF) from the left seat. The three passengers occupied the rear compartment in seats spaced evenly across the helicopter. A normal start was accomplished and all systems functioned normally, with the exception of the automatic direction finder, which was not essential for the flight. After start, the crew set the altimeters to 29.63. The altimeter of the PF indicated 90 feet asl and that of the PNF 150 feet asl. The crew set the radio altimeters to 200 feet above ground level (agl) in accordance with company standard operating procedures (SOPs). The helicopter was heading 165° on the pad, and the departure heading was set at 280°. The PF gave a take-off briefing indicating that he would take off vertically, bring the helicopter to the hover while turning about 90° to the right, and that the climb performance would be limited.

The PF brought the helicopter to a low hover and simultaneously turned to the right to establish the departure heading. The helicopter is seen clearly in the security video during start-up and initial low hover. The PNF monitored the instruments and made advisory calls to the PF regarding the position and performance of the helicopter. When the helicopter was established in the low hover, the transmission torque was called by the PNF at 85% to 86%, indicating that up to 15% additional torque was available for take-off.

The maximum power allowed by the aircraft flight manual (AFM) during take-off is 15% torque above hover torque. While climbing to the low hover, the PF allowed the helicopter to drift rearward, still positioned over the pad. The PF then began to climb vertically, and the recirculating snow completely obscured the helicopter in the security video. Both pilots were able to discern ground references and see the pad lights. The maximum torque limit of 100% was reached within 15 seconds and the vertical climb stopped.

For the next 15 seconds, visual references in the vicinity of the pad were mentioned by both pilots while the helicopter was hovered above the pad. The PNF then indicated concern about movement of the helicopter rearward toward some of the site's structures, and urged the PF to move forward in departure. Torque reached 105% as the helicopter started to move forward. Although still nearly obscured by recirculating snow, the helicopter's movement can be discerned in the security system video.

The helicopter moved at a constant height, approximately 20 feet agl, from the rear of the pad until it disappeared from view at the intended departure end of the pad. As the helicopter moved forward, the PNF instructed the PF to put the nose down a little, and called a torque of 110%. The PF did not respond and made no further calls or responses for the remaining 15 seconds of flight. The collective was nudged down by the PNF who then called the torque at 100%. When the pad lights disappeared, the PNF was looking completely inside and believed that outside visual references had been lost in white-out, even though the helicopter had moved out of the recirculating snow.

About two seconds after calling the torque at 100%, the PNF called the helicopter climbing and the airspeed alive at 40 knots. The PNF then instructed the PF to keep climbing and, approximately five seconds later, called a warning about heading and that the helicopter was rolling left. Almost immediately, the helicopter struck the terrain. Information obtained from the global positioning system indicates that the helicopter flew at a forward speed in excess of 30 knots for about 18 seconds.

Ground scars made during the crash were obliterated by a blizzard before they could be examined by Transportation Safety Board (TSB) investigators. However, information provided by a survivor indicated that the ground scar from the left skid was significantly longer than the scar from the right skid. The skids had broken through the frozen surface of a pond, and the pop-out floats had deployed.

The wreckage was found upright with the left skid rolled under the main body. Pieces of wreckage were found about 250 metres from the pad, and the main wreckage was about 100 metres further on. The right skid was torn off and there was substantial impact damage to the underside of the nose area. The transmission had separated from its mounts and was found to the right side of the main wreckage. The main rotor blades had separated from the head and had broken and debonded. The damage to the main rotor blades and transmission were consistent with high engine power at the time of impact. The wreckage was examined to the extent possible, given the remote location and the inability to lift the wreckage; no pre-impact anomalies were found.

Aircraft Instruments

The emergency locator transmitter (ELT) did not activate on impact; it was found damaged on the cockpit floor. Examination of the cockpit area revealed that the main rotor blade had struck the right cockpit area damaging the ELT. The digital cockpit voice recorder (CVR) was found in the baggage compartment, undamaged but disconnected from its power source. The CVR was played at the TSB Engineering Branch Laboratory. The cockpit conversations and ambient sounds both from the previous day's flight and from the accident flight were retrieved. The segment from the accident flight began with the pre-start and continued until aircraft power was disrupted at impact. The helicopter was not equipped with a flight data recorder, nor was one required by regulation.

The helicopter was equipped with dual flight instruments, including dual radio altimeters. The vertical speed indicators (VSIs) were standard VSIs and not instantaneous vertical speed indicators (IVSIs). The primary power instruments were also dual, and consisted of torque and rpm gauges. The helicopter was equipped with a force trim system, and a stability and control augmentation system. The helicopter was also equipped with an automatic flight control system, which was not to be used below 40 knots.

The pilot's pressure altimeter, VSI, radio altimeter, attitude indicator, airspeed indicator, and horizontal situation indicator were functionally tested at the TSB Engineering Branch Laboratory and found to be serviceable. Examination of the instruments did not reveal any conclusive markings as to their indications at the time of impact.

Helicopter Procedures in Whiteout Conditions

The SOPs for NWS operations for take-offs in whiteout or low-light conditions direct that the following take-off procedure shall be used:

1. Take-off checks complete
2. Radio altimeter set to 200 feet
3. Radio calls and PNF duties complete
4. Lift off into low stabilized hover and check power
5. Continue upward from low hover - through 30 feet PNF calls “Rotate”
6. PF rotates nose-down approximately 5 degrees - (priority is rate of climb) -PNF calls “Positive Rate of Climb”
7. As airspeed builds - PNF calls “Airspeed live” - “40 knots” - “58 knots”
8. As altitude increases - PNF calls “100 ft” increments to 500 ft
9. PF adjusts attitude to climb at 70 knots at 80% torque
10. No turns below 500 feet
11. Only essential radio calls and no cockpit checks until 1000 feet
12. Through 1000 agl both radio altimeters shall be set to 1000 feet en route

Transport Canada’s *Aeronautical Information Publication*, section Air 2.12.7, describes whiteout as an extremely hazardous visual flight condition. Whiteout occurs over an unbroken snow cover and beneath a uniformly overcast sky. Because the light is diffused, the sky and terrain blend imperceptibly into one another, obliterating the horizon. The horizon, shadows, and clouds are not discernible, and sense of depth and orientation is lost; only very dark, nearby objects can be seen.

The real hazard in whiteout is that pilots do not suspect the phenomenon because they may be in clear air. In many whiteout accidents, pilots have flown into snow-covered surfaces unaware that they have been descending, and confident that they could see the surface. Consequently, when pilots encounter the whiteout conditions described above, or even suspect they are in such conditions, they should immediately climb if at low level, or level off and turn toward an area where sharp terrain features exist. Pilots should not continue the flight unless they are prepared to cross the whiteout area using instruments and have the training and qualifications to do so.

The Transport Canada (TC) Instrument Manual - TP2076E covers helicopter instrument flying techniques and instrument take-off (ITO) procedures. The manual describes an ITO as a composite visual/instrument procedure, assuming a two-pilot crew. It states that the ITO must be completed with one pilot monitoring the flight instruments and the other looking at outside visual references. The manual stresses that the crew must ensure there is a positive rate-of-climb before transitioning into forward flight and warns that early rotation of the helicopter, before a positive rate-of-climb is established, has resulted in helicopter accidents. Pilots should monitor initially the vertical speed indicator and then the altimeter for a positive rate- of-climb schedule.

In a discussion of the type of instrument cross-check to be used, the manual notes that due to the helicopter’s ability to climb, descend, and change heading without a corresponding change in attitude, the cross-check is hampered if prolonged ‘eye rest’ on the attitude indicator is employed. The manual also notes that most IFR-certificated helicopters are equipped with an IVSI. The design of the IVSI can assist the pilot in flying IFR as it is an effective pitch instrument. Compared to the conventional VSI, the IVSI has no apparent lag. In discussing power settings as controlled by the collective lever and displayed on the torquemeter, the manual indicates that when power is reduced in a helicopter of North American manufacture, the nose will pitch down and yaw to the left.

As part of an effort to investigate rotorcraft accidents involving collisions with obstructions, the United States Federal Aviation Administration (FAA) sponsored the preparation of a report based on analysis, ground-based simulation, and flight testing of rotorcraft flying qualities in degraded visual environments. The report indicates that the primary cue for stabilization in the low speed and hover flight regime is micro texture or fine-grained detail rather than large objects.

Snow-covered terrain, particularly when snow is blown up by rotor wash, is an environment lacking micro texture and one in which controllability problems can be expected. The report concludes that the degraded handling characteristics can increase the workload in excess of 100% of the pilot's capacity, and this situation significantly increases the probability of serious error. The report found that increased stabilization has a substantial positive effect of reducing pilot workload in conditions of degraded visual cueing and recommended the use of attitude stabilization in such conditions. The report also suggested that an education program be undertaken to improve awareness of the danger of low speed and hover operations in areas of minimal visual cueing.

Pilot Qualifications

The captain held a valid airline transport pilot licence for helicopters. The licence was endorsed for the Bell 212 with a Group 4 instrument rating. Company records indicated that the captain had over 6949 hours total time with approximately 1600 hours on the Bell 212. He had flown about 29.8 hours in the last 30 days and 21.8 hours instrument in the last year. He was in the first week of a four-week deployment to the Arctic. In the 24-hour period prior to the accident, the captain had acted as the PF on the previous flight. The flight had returned about 1400 in the afternoon and the captain retired about 2200.

The first officer held a valid airline transport pilot licence for helicopters. The licence was endorsed for the Bell 212 with a current Group 4 instrument rating. Company records indicated that the first officer had over 13 000 hours total time on several helicopter types and had 42 hours on the Bell 212. He had flown about 32 hours in the last 30 days and 3.7 hours instrument in the last year. He was in the last week of a four-week deployment to the Arctic. In the 24-hour period prior to the accident, the first officer had acted as the PNF on the previous flight and retired to his quarters about 2200.

The first officer had completed his training on the Bell 212 in the two months before the accident. He had received training in vertical take-offs at Villeneuve, Alberta, a small airport north of Edmonton. Departures were made at night from the end of a runway to simulate lack of visual references. He did not receive any simulator training.

The captain had assisted in the training of the first officer. The captain had also practised take-offs at Villeneuve and did not consider the training ideal because of lights in the area around the airport. He had also received simulator training.

Aircraft Weight and Balance

No record of weight and balance computations for the flight could be found. After the accident, a weight and balance was computed using estimated weights and information obtained during the investigation. It was concluded that the take-off weight was under the maximum allowable all up weight and the centre of gravity was within the required range for IFR flight.

Analysis

The environmental conditions within and surrounding the North Warning System site were deceptive. Objects, including the hanger ½ mile away, could be seen clearly. As stated in Transport Canada's *Aeronautical Information Publication*, the real hazard in whiteout is that pilots do not suspect the phenomenon because they may be in clear air. The crew did not discuss the whiteout hazard; however, the crew correctly identified the loose snow as an imminent danger because of the recirculation anticipated and planned a vertical take-off. The vertical take-off itself should have reduced the threat of white-out; however, the crew did not consider any other defence.

The chosen departure path had three advantages: it was in the direction of the destination, it was clear of artificial obstacles that would be obscured in recirculating snow, and it had the additional safety factor of the terrain sloping downward. Conversely, the departure path had several disadvantages: the wind, while light, was at 90° to the take-off heading; the hanger, which was ½ mile away, could not be seen on the take-off heading and could not be used for attitude reference; and, the terrain in the direction of flight was featureless with no visible horizon. The choice of departure path increased the threat of white-out.

The 15% torque margin available in the low hover indicates that the helicopter had the performance available to safely accomplish the take-off and departure. However, both the Instrument Procedures Manual and the company's standard operation procedures (SOPs) stress that the priority is rate-of-climb before rotation. Information from the video and the cockpit voice recorder indicates that the available power was used to bring the helicopter into a high hover, a hover in which the helicopter was allowed to drift backwards.

The crew spent some 15 seconds while drifting over the pad discussing visual references. This expended the vertical momentum of the helicopter, and when rotation was made to transition to forward flight the helicopter was in level flight. The rushed nature of the rotation is indicated not only by the sense of urgency of the PNF, but also by the over-torque of 10% above the maximum allowable torque of 100%. Because the vertical take-off was not executed in accordance with the SOPs, the time that the helicopter was in the recirculating snow was extended, and this occurred while in close proximity to the terrain as the helicopter moved into the white-out conditions.

Although the PNF called climbing, information from the video, and short time of flight before the helicopter struck the terrain, indicate that it is unlikely that a positive climb rate had been established. Several factors could have caused the PNF to misidentify a climb. First, a standard vertical speed indicator can lag the true vertical movement of the helicopter. It can also bounce misleadingly in the recirculating air. Secondly, the radio altimeter would have shown an increase as the helicopter moved over the terrain sloping away from the pad. Thirdly, the altimeter of the PNF had read 150 feet while on the pad which was actually at 135 feet; this could give the appearance of a climb. Additionally, the instruction by the PNF to keep climbing could indicate that he was not certain that a positive rate had been properly established. Because the radio altimeter was set to 200 feet above ground level, the decision height light would have remained on throughout the procedure and would have given no indication as the helicopter descended into the terrain. An instantaneous vertical speed indicator would have given the crew more timely information about the helicopter's vertical movement.

Although the crew were using the stability and control augmentation system as recommended in the Federal Aviation Authority's study, the amount of coaching by the PNF and the lack of responses from the PF during the transition indicate that the PF was becoming task saturated and likely unsure of his attitude references. When the PNF made the power change from 110% to 100% there would have been a tendency for the helicopter to pitch down and yaw to the left. Likely close to task saturation, the PF did not compensate for these tendencies quickly enough, and the helicopter lost the remaining terrain clearance and struck the terrain in a nose-low, left-banked attitude.

Once the decision was made to rotate into the transition after vertical momentum had been lost, the crew needed to establish and maintain a positive rate-of-climb. Some seven seconds prior to impact, the PNF interpreted instrument readings to indicated that the helicopter was climbing. The crew then attempted to maintain that attitude to climb away. The primary focus was on maintaining that attitude, even though in reality the helicopter must have been descending. Consequently, as indicated in the Transport Canada instrument manual, the crew's cross-check was hampered by prolonged 'eye rest' on the attitude indicator. The slow instrument scan did not provide the crew with the information needed to stop the descent into the terrain. Contributing factors were the proximity to the terrain, the loss of vertical momentum, and the 10% reduction in power.

The crew were very experienced helicopter pilots; however, the PF had limited time on type. This likely contributed to his lack of proficiency in accomplishing a vertical take-off and also increased his workload. Neither pilot had significant recent instrument experience, and the training of both pilots in this type of departure had been conducted in an area with external visual cues. These factors may have accounted for the tendency for prolonged 'eye rest' on the attitude indicator and the slow instrument scan.

The following Engineering Branch reports were completed:

LP 153/2004 - GPS Analysis
LP 156/2004 - Examination of Fractured Rod End
LP 159/2004 - Instruments Analysis

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

Findings as to Causes and Contributing Factors

1. The helicopter departed into environmental conditions conducive to white-out and loss of micro texture for attitude reference.

2. The potential for entering white-out conditions was masked by the visibility of objects in the vicinity of the departure point.

3. The crew did not maintain the priority of rate-of-climb during the rotation to forward flight, did not maintain an adequate instrument scan, and were not able to overcome the white-out conditions and establish a positive rate-of-climb.

Findings as to Risk

1. The helicopter was not equipped with an instantaneous vertical speed indicator, nor was one required. Transitory false indications of a climb were possible from the vertical speed indicator installed in the helicopter.

2. The crew's training was conducted in a setting that did not demonstrate the effects of lack of micro texture, and the crew did not anticipate white-out other than the effects of recirculating snow.

3. The crew's training did not develop the rapid instrument scan required to compensate for the pilot flying's minimal experience on type and in arctic conditions.

Other Finding

1. The emergency locator transmitter was damaged and rendered inoperative when the main rotor struck the cockpit area.

Safety Action Taken

As part of its safety management system, Canadian Helicopters Limited completed an internal investigation to draw lessons from this occurrence. It has increased its use of full-motion flight simulator training to help replicate departures under white-out conditions and to monitor flight crew interaction. Following a review of its existing standard operating procedures, simulator training will also emphasize compliance. The company has instituted a policy requiring a minimum of 50 hours on type before pilots perform departures under white-out conditions.

It is assessing the use of low-profile reflective markers at Northern Warning System helipads to provide additional visual cues along departure and approach paths.

This report concludes the Transportation Safety Board's investigation into this occurrence. Consequently, the Board authorized the release of this report on 28 July 2005.