AVIATION INVESTIGATION REPORT
A99C0087

COLLISION WITH TERRAIN

POINTS NORTH AIR SERVICES
DE HAVILLAND DHC-3 C-FASV
POINTS NORTH LANDING, SASKATCHEWAN 22 NM NW
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Summary

The wheel-ski equipped de Havilland DHC-3 Otter, C-FASV, serial number 23, was engaged in flying road construction crews from base camps to work sites in northern Saskatchewan. A five-man crew was moved from a base camp to a small lake, about 22 nautical miles (nm) from Points North Landing, Saskatchewan, the company's main base. The drop-off was made in the morning with a pick-up planned for late afternoon. The pilot then flew back to Points North Landing and filled the aircraft's fuel tanks from the company's main fuel supply. When the pilot returned for the pick-up, the ambient temperature was about seven degrees Celsius, and there were between five and six inches of slush on the ice surface. The pilot loaded the passengers and attempted a take-off. The aircraft accelerated slowly in the slush, and the pilot rejected the take-off. He selected a different take-off run, moved a passenger to a forward seat, and attempted a second take-off. The pilot continued beyond his previously selected rejection distance. The engine revolutions per minute (rpm) then reportedly decreased by about 150 rpm. The aircraft did not become airborne, and it ran into the low shoreline and crashed, skidding to a stop about 300 feet from the shore. An intense fire broke out immediately. The passengers and pilot evacuated the aircraft. Only one passenger suffered minor burns during the evacuation. Flames engulfed the main fuselage and engine, destroying the aircraft.

Ce rapport est également disponible en français.

Other Factual Information

At Points North Landing, the pilot loaded a small amount of cargo and filled the aircraft tanks to complete an anticipated four-day deployment and avoid transporting drums of fuel to the remote camps. He then flew to the pick-up lake, which had been used for several days in a row. The pilot loaded the passengers and attempted a take-off starting at the pick-up point towards the lowest terrain of the far shoreline. The aircraft accelerated slowly in the slush, the tail was slow to come up, and the pilot rejected the take-off after travelling about two thirds of the surface run available. He then taxied back to a different position to obtain the longest take-off run available. He also moved a heavy passenger to a forward seat in order to bring the tail up more quickly and attempted a second take-off along the tracks made during the backtrack. The tail of the aircraft came up more quickly on the second run, and he continued beyond his previously selected rejection point. Although the aircraft was not yet airborne, the pilot believed that the aircraft would fly. He reported that the engine rpm decreased by about 150 rpm, but he had no room to stop. He continued the take-off run believing that the aircraft would become airborne before reaching the shoreline. The aircraft did not become airborne and crashed into the rocks on the shore. The pilot attempted to hold the nose of the aircraft up and the aircraft bounced into low scrub trees on the shore. The aircraft then skidded to a stop about 300 feet from the shoreline and a fire broke out.

The weather at the time of the accident was overcast, winds calm, and temperature approximately seven degrees Celsius. The weather at Stony Rapids, approximately 60 nm to the northwest, was reported as 1800 feet overcast, visibility 15 statute miles, winds calm, temperature five degrees Celsius, dewpoint 1.9 degrees Celsius, and altimeter 29.63 inches of mercury.

According to the flight manual, the take-off engine rpm is 2250; no acceptable degree of variation from this rpm is mentioned. Over a period of 10 days before the occurrence, the occurrence pilot had noted that the engine rpm had decreased from 2250 rpm during take-off and stabilized at 2000 rpm on numerous occasions. In the past, engine performance had been adequate for operating at the occurrence lake, and the pilot had accepted that decrease in performance as routine. With the conditions that existed on the day of the occurrence, the pilot continued to believe that the engine performance was adequate and decided to continue operations to the lake. The pilot did not note the take-off rpm variation as a defect in the aircraft's log book.

The aircraft's skis left tracks in the slush on the frozen surface of the lake during the two take-off attempts. The first run began from the road access at the southwest corner of the lake, which headed east directly across the lake towards the lowest terrain. The available surface run was about 1800 feet long. The ski tracks indicated that the tail of the aircraft came up about halfway across the lake and then came down at about 400 feet from the shoreline. The ski tracks of the aircraft then indicated that an approximately 180-degree turn was completed about 90 feet from shore. After the turn, the ski tracks led to the northwest corner of the lake. The tracks indicated a take-off run heading more southerly than the first run. The run was slightly longer than the first, about 2000 feet, but had the disadvantage of heading towards more steeply rising terrain. The ski tracks of the last take-off remained in the tracks made on taxi back until about halfway across the lake. The track of the tail ski indicated that the tail was up before the halfway point was reached, but the tracks of the main skis were both visible until about 400 feet from the shoreline. At this point, the left ski track appeared to increase in depth, leaving a darker track, but the right ski track stopped, then started again at about 130 feet from the shoreline and continued for about 50 feet. The track of the tail ski started again about 90 feet from shore and remained in contact to the shore line. The tracks led directly to the start of the wreckage trail on the shoreline.

When collision with the shoreline became inevitable, the pilot turned off the magneto switches. The aircraft was propelled into the air on contact with the shoreline and travelled approximately 100 to 150 feet before it contacted the ground again. Trees of up to three inches in diameter were diagonally cut by the propeller blades. The propeller blades also came in contact with the ground and embedded rocks. The tips of two propeller blades showed damage consistent with high rpm. Measurement of the number-one propeller blade in relation to impact marks on its shim plates indicated that the blade was at 18.5 degrees, the fine-pitch limit. The extent of fire damage precluded an assessment of the propeller control's position or of the propeller governor's performance. The fine-pitch blade angle is consistent with the propeller governor attempting to regain engine/propeller rpm after the magnetos were turned off. The tree cuts at the site, the propeller blade tip damage, and the fine-pitch blade angle indicated that the propeller had high rotational energy but was in a condition to promote an increase of engine/propeller rpm at the time the propeller struck the ground.

The fire destroyed the aircraft from the engine's rear accessory case to the rear door frame and to approximately four feet outboard of the wing root of both wings. Each wing's outboard section had dropped directly down and came to rest on the ground, perpendicular to the burned out fuselage. The tail section of the aircraft was undamaged. It remained upright, in line with the burned portion of the fuselage. The fire damage to the engine and accessories was extensive, making it impossible to test the propeller governor or magneto accessories.

The engine cylinders and nose case appeared to be intact, and the propeller remained attached to the drive shaft of the engine. The left wheel-ski showed bending as a result of impact with the shoreline. Teflon was transferred from the bottom of the ski to rocks at the shoreline at the point of impact. All accessories mounted on the engine's rear accessory case as well as the rear accessory case itself were destroyed by fire.

The maximum allowable gross weight of the aircraft was 8000 pounds. The journey logbook was destroyed in the accident, and an accurate weight and balance could not be computed. However, available information indicated that the aircraft weighed about 7672 pounds on take-off from the lake and that the aircraft's centre of gravity was within limits. On the occurrence take-off, the fuel weight was estimated to be about 1150 pounds, and the freight weighed about 100 pounds. The pilot had flown into the lake on the two days immediately before the accident day. The day before, the aircraft had the same passenger load, a fuel load of about 366 pounds, no freight and was about 884 pounds or about 10 per cent lighter.
Transport Canada (TC) publication TP4441E, *Light Aircraft Operating Tips*, acknowledges that light aircraft often operate off shorter runways that do not provide full accelerate-stop distances. The publication recommends that take-off should be accomplished within the first 75 per cent of the useable distance. TC further recommends that the pilot should reduce weight, or delay the take-off until winds and density altitudes are more favourable if the 75 per cent rule cannot be met.

The DHC-3 Otter aircraft flight manual (AFM) contains limited information on ski operations. Section 7, "All Weather Operation", states: "Carry out a precautionary type of take-off from unpacked snow or slush as the rate of acceleration is poor under these circumstances".

While a precautionary type of approach is not defined, the recommendations made by TC in TP4441E would be prudent to follow in unpacked snow or slush.

The National Research Council of Canada (NRC) report MM-225, *Aircraft Ski Research in Canada*, discusses the comprehensive research programme aimed at the development of improved skis for aircraft and provides information about the use of skis. The following paragraph paraphrases relevant portions of the publication:

> Early in the tests, it was found that sliding resistance and adhesion were far more dependent upon snow conditions than on the design of the ski. Further, the skiing quality of the snow changed continually and it was not unusual to observe marked changes taking place in less than an hour. The publication notes that there are times when the sliding resistance of aircraft skis is so great that it is impossible to reach flying speed. It was found that the sliding resistance of a ski could be divided into (a) the resistance component due to compacting the snow while forming the ski track, analogous to form drag in aerodynamics, and (b) the resistance component due to friction. In the case of dry snow, the ski resistance is considered to be made up of (a) solid friction, most of which occurs near the toe of the ski, (b) viscous drag due to shearing in the very thin film of water between the ski and the areas of contact, and (c) drag due to surface tension forces acting at the perimeters of the water drops in contact with the ski bottom. In very wet snow, the entire bottom of the ski is wet and most of the resistance is due to viscous drag, which varies as the square of the speed. All three components of ski friction — solid friction, viscous drag, and surface tension drag — increase with an increase in contact between the ski and snow and are therefore greater for soft snow than for hard snow.

The pilot held a commercial licence. His medical certificate was valid and required that glasses be available. The pilot was not wearing glasses at the time of the accident, but reportedly had no difficulty seeing cockpit instrumentation. The pilot had in excess of 20 000 hours of flying time accumulated over a 35-year flying career. He had about 6400 hours on the Otter aircraft in bush operations similar to the accident flight. He had flown 13.3 hours in the last 7 days, 30 hours in the last 30 days, and had accumulated 76.2 hours in the last 90 days. On the day of the accident, he was reportedly well rested and had spent most of the day at the main operating base where he had refuelled the aircraft. Information indicated that he felt under no pressure by the company to overload the aircraft or press the weather. The pilot's experience had been key to his engagement by the company because his flights were conducted mostly from remote sites and supervision was not practical. Records did not indicate any difficulties in the pilot's flying background.

Analysis

The extent of fire damage to the engine and to the propeller components precluded an assessment of the propeller governor's performance other than to establish that the propeller was in fine pitch, in the governing range, and at high rpm during the collision with the shoreline. However, aerial photography of the aircraft's ski tracks and other information provided substantial details concerning the two take-off attempts by the pilot. The two significant performance factors in wet slushy conditions are the up-slope effect or form drag from the slush build-up in front of the ski and viscous drag from water contact over the entire bottom surface of the ski. Both factors can combine to make take-off impossible, and once a small lake with short take-off runs had been selected for use, the pilot had to consider these two factors in his decision making. Consequently, the analysis will deal primarily with pilot decision making and the performance of skis in slush.

The pilot had operated to the lake during the two days before the accident. Conditions had been warm, but not as warm as the day of the accident, and the slush was reportedly not as deep. The aircraft weighed about 800 pounds less than the occurrence aircraft, and the pilot had no difficulty operating in and out of the lake. He decided to carry enough fuel to complete a four-day deployment and, as a result, he filled the aircraft's fuel tanks.

The decisions regarding fuelling, operating in the conditions of the lake, and moving the road crew by air rested solely with the pilot. Because he had made decisions that affected the continued operation to the lake, there was a possibility of self-induced pressure to carry out the crew pick-up rather than inconvenience the crew.

The pilot then made the first of two take-off attempts. The ski tracks indicated that he began his take-off from the pick-up point towards low terrain across the lake. The pilot used about two thirds of the take-off run as a reject point. When the aircraft reached this point and was not airborne, the pilot rejected the take-off. The aircraft decelerated, and the ski tracks indicated that he was able to turn the aircraft and approach within about 90 feet of the shoreline. The pilot's decision to reject was consistent with recommended practices and met the AFM requirement for a precautionary take-off.

The pilot decided to attempt another take-off from a different position on the lake. While he made a small gain in take-off run available and had the advantage of taking off in the ski tracks made by the backtrack, the direction he chose headed towards faster rising shoreline than his original run. He reasoned that he would improve performance if he could get the aircraft's tail up faster, so he moved a passenger from the rear of the cabin to the front to change the centre of gravity and assist in raising the tail.

While the choice of take-off path and the making of tracks for the skis increased the chances of a successful take-off, the effect of the change in the centre of gravity was questionable; the penetration of the main skis into the slush remained roughly the same, but this change increased the weight placed on the main skis. Viscous friction was not changed by the movement of the weight. Only a weight reduction would have accomplished the required increase in performance. Consequently, when the pilot arrived at his decision point, the aircraft was not airborne. However, the tail had now come up sooner and the pilot, convinced that the aircraft would fly off, continued past his previously predetermined reject point. Continuing past this point was not consistent with recommended practices and did not satisfy the AFM requirement for a precautionary take-off.

Information indicated that the engine then performed as it had for the previous 10 days; that is, the engine rpm rolled back. The pilot was able to raise the right ski, and his belief that take-off was possible was reinforced. When the right ski was raised, the pressure on the left ski increased, as demonstrated by the deepening track. The departure path then curved to the left and the skis left the tracks created during the backtrack. Throughout the entire attempt, the left ski did not leave the surface, and the right ski contacted the surface at least once after being raised. The available information indicated that the aircraft had little chance of becoming airborne and that the pilot persisted in the belief that the aircraft would fly even when it became clear that the take-off could not be completed and collision with the terrain at the edge of the lake was imminent.

The pilot's decision reflected a belief that the changes he had made would ensure the aircraft became airborne. In a series of sequential, related decisions, there is a tendency not to change or modify the preceding decision as readily as the available information would otherwise suggest prudent. This apparent reluctance to adapt may be in part because of a possible state of expectancy or predisposition (mind-set) which can distort what is perceived.

Findings

1. The pilot was qualified and certified for the flight in accordance with existing regulations.

2. The weight and centre of gravity of the airplane were likely within the prescribed limits.

3. The left ski remained in contact with the slush on the ice surface throughout the second take-off run.

4. The pilot continued the take-off beyond the point at which a safe reject could have been made.

5. The pilot noted a decrease in engine rpm beyond the point at which a safe reject could have been made.

6. The condition of the engine and accessory gearbox precluded any useful analysis of the amount of power the engine was producing.

Causes and Contributing Factors

The pilot continued the take-off run with the left ski firmly adhering to the slushy surface beyond a point at which a reject could have been made safely. Contributing to the occurrence was the decrease in engine rpm during take-off.

This report concludes the Transportation Safety Board's investigation into this occurrence. Consequently, the Board authorized the release of this report on 09 May 2000.