Transportation Safety Board of Canada

Bureau de la sécurité des transports du Canada

AVIATION INVESTIGATION REPORT
A00Q0006

COLLISION WITH THE GROUND

CARGAIR LTD.
de HAVILLAND DHC-2 Mk.1 BEAVER C-FIVA
LAKE ADONIS, QUEBEC
13 JANUARY 2000

Canada

Aviation Investigation Report

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Cargair Ltd.
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Summary

The DHC-2 Mk. 1 skiplane, registration C-FIVA, serial number 515, with the pilot and five passengers on board, took off from the frozen surface of Lake Adonis, Quebec, on a pleasure flight under visual flight rules (VFR). The route had not been determined, but the flight was to last about 20 minutes. When the aircraft did not return, the search and rescue (SAR) service was advised. The aircraft was found crashed on a mountainside in a wooded area a little less than five kilometres from its point of departure. The pilot and two passengers suffered fatal injuries. The other three passengers suffered serious injuries and hypothermia. The aircraft was destroyed by the force of the impact but did not catch fire.

Ce rapport est également disponible en français.

Other Factual Information

On 13 January 2000, around 0830 eastern standard time (EST),[1] the pilot of C-FIVA took off from Cargair Ltd.'s main base of operations on Lake Kaiagamac at Saint-Michel-des-Saints, Quebec. The day's itinerary was to proceed to 100 Lacs Outfitter on Lake Adonis, about 57 nautical miles north-west of Saint-Michel-des-Saints, for two pleasure flights with a group of tourists. The pilot was then to proceed to Lake Prévost, 16 nautical miles south-west of Lake Adonis, for three more pleasure flights. On the return trip to Saint-Michel-des-Saints, the pilot was to pick up a passenger at the Manouane Reserve. According to the flight itinerary, the pilot was to return to the main base around 1600.

The aircraft touched down on Lake Adonis around 0930. The pilot shut down the engine before having the passengers board. The regulations require that pilots brief passengers on the aircraft and its equipment before take-off. Pilots must show passengers how to use the seat belts and shoulder belts. They must also specify the location of emergency equipment the passengers may need in an emergency situation, such as the emergency locator transmitter (ELT), fire extinguisher, survival equipment (including the means to access if in a locked compartment), first aid kit, and life raft. According to the information gathered, the passengers' pre-flight briefing addressed only the use of seat belts and shoulder belts. All the occupants were wearing their safety belts except one passenger who had been unable to buckle his.

Around 0945, the aircraft, with the pilot and five passengers on board, took off from the frozen surface of the north-west tip of Lake Adonis on the first pleasure flight. The aircraft took off normally towards the south-east and then flew low over Lake Adonis at less than 200 feet above ground level. The aircraft then headed south-west over the lake and disappeared from view behind the rugged terrain. The pilot then flew the aircraft north-west towards the rising terrain. The aircraft flew over the rising terrain for about 1 700 metres before hitting trees. The engine was apparently functioning normally before the crash. The flight had lasted less than 10 minutes. When the aircraft did not return to the outfitter's 30 minutes after departure, searches were initiated to locate it but to no avail. The aircraft was reported missing to the SAR staff around 1105 and was found around 1437, crashed on a mountainside in a wooded area less the five kilometres from the outfitter's.

A few seconds before impact, the aircraft had banked abruptly to the left. The aircraft cut a swath approximately 20 metres long through the trees, on a path corresponding to an entry heading of 300 degrees magnetic. The aircraft then struck the ground at an angle of about 50 degrees and came to rest upside-down on a heading of 225 degrees magnetic, about 100 metres south of a mountain peak.

The wreckage distribution at the accident site and the information gathered reveal that the airplane stalled. All control surfaces were accounted for, and all damage to the aircraft was due to the severe impact forces. The flaps were up, which agrees with the position of the flap selector lever and position indicator. The fuselage exhibited little deformation aft of the two front seats. The investigation showed that the engine was producing power at the time of

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[1] All times are EST (coordinated universal time [UTC] minus five hours).

impact and that the damage was all associated with the impact. The witness marks left by the propeller confirm that the blade was at a low-pitch angle, which corresponds with normal flying power. The power of the engine, however, could not be precisely determined based on examination of the wreckage.

The company operations manual states that if an aeroplane has not arrived at destination within the hour following its estimated time of arrival and no flight plan was filed with air traffic services, SAR will be advised after reasonable attempts have been made to communicate with the pilot-in-command. The aircraft was equipped with a fixed ELT. The ELT was able to transmit a distress signal after impact, but the signal's range was considerably reduced because the antenna broke in the accident. The signal was therefore not received by the SAR satellite-aided tracking system. Although there was a sign posted in the cabin concerning the location and operation of the ELT, the passengers were not asked to read it and were not orally briefed on its use and location. Locating the mostly white aircraft was also made difficult because the aircraft blended into the snowy ground. The rescuers found all the occupants trapped inside the aircraft, except for one passenger who managed to get out. The pilot and two of the passengers were already dead. The survivors suffered fractures and hypothermia.

The inspection of the accident site revealed that the survival equipment on board met regulation requirements. The equipment was in the rear of the aircraft, behind a panel separating the cabin from the baggage compartment. The location and details of this equipment were unknown to the passengers because no mention was made of it in the pre-flight briefing. The brochure *A Safety Guide for Aircraft Charter Passengers* (TP 7087), distributed on request or at certain presentations given by Transport Canada, aims to increase passengers' safety awareness in small aircraft. The brochure contains information on the importance of asking about the location and operation of safety equipment, such as survival equipment and the ELT. There is no indication that the passengers had heard of this brochure.

At the time of the accident, the weather conditions were suitable for visual flight. Visibility was greater than 15 miles, the winds were light from the north-west, the temperature was about minus 25 degrees Celsius, clouds were scattered, and there was no precipitation.

The pilot was certified and qualified for the flight. He held a commercial pilot (aeroplane) licence since 26 March 1991. According to the company operations manual, Cargair Ltd. is to provide its pilots with annual flight training for them to keep their competence up to date. The pilot had completed his most recent annual DHC-2 flight training on 03 May 1999. The last entry recorded in the pilot's personal logbook indicates that, as of 05 October 1999, he had accumulated a total of 3 417 hours' flying time and that most of his flying experience was on the DHC-2 and the DHC-3. The pilot also held a category M1 aircraft maintenance engineer licence. He had worked for the company for more than 10 years and had the reputation of being a cautious pilot. According to the autopsy and toxicological test results, there was no indication that physiological factors affected the pilot's performance.

The morning of the accident, the pilot appeared to be well rested. On departure from Saint-Michel-des-Saints, the pilot refuelled the aircraft. He then discussed the planned itinerary with the dispatcher and decided to add an undetermined amount of fuel. The company has its own fuel distribution system. The pilots fuel their own aircraft from a metered pump showing the number of litres taken on. The company does not maintain a control or billing system to

track the exact quantity of fuel taken on by each aircraft using the distribution system, and the regulations do not require such a system. It was not possible to determine exactly how much fuel was on board the aircraft when it crashed because the tanks drained after impact. However, on the day of the accident, the DHC-2 was the only aircraft to refuel. The pump meter is normally reset before each use; it read 341 litres after the refuelling.

Because refuelling was not available en route or at the planned stops, the pilot had to carry a sufficient quantity of fuel to return to the base plus a 30-minute allowance. Based on the normal fuel consumption and taking into account the estimated time en route and the fuel allowance, the minimum quantity of fuel required on departure from Saint-Michel-des-Saints was approximately 300 litres. According to calculations, a total of 21 litres remained in the aircraft's tanks on return from the last flight made on 10 January 2000. Adding these 21 litres to the meter reading of 341 litres, the aircraft would have taken off from Saint-Michel-des-Saints with a minimum of 362 litres on board, which corresponds to the total amount of the three main tanks under the cabin floor. In addition to these three main tanks, the aircraft was fitted with a belly tank capable of holding 163 litres. Based on the information gathered, this tank did not contain any fuel on departure from Saint-Michel-des-Saints; it is used only for long trips. In flight, to keep the aircraft's centre of gravity within the prescribed limits, the pilot usually uses the fuel in the three tanks consecutively from the rear to the front, selecting the desired tank with a selector valve in the cockpit. During the inspection of the aircraft at the crash site, the selector valve was in the REAR position. Based on normal consumption, there should have been approximately 33 litres left in this tank.

The aircraft was certified, equipped, and maintained in accordance with existing regulations and approved procedures. The aircraft had flown a total of 24 600 hours as of 10 January 2000. The last annual inspection was in November 1999. The pilot held an aircraft maintenance engineer licence, had been actively involved in the annual inspection, and had signed the technical documents. During this inspection, the floats were replaced with skis for winter operation. The aircraft had accumulated a little less than four hours since this last inspection.

There is no indication that the aircraft's weight and balance were calculated on departure from Lake Adonis. Calculations using the actual weight of the passengers, the estimated amount of fuel taken on board on departure from Saint-Michel-des-Saints, and normal fuel consumption for the trip between Saint-Michel-des-Saints and Lake Adonis confirmed that the aircraft's weight and centre of gravity on take-off at Lake Adonis were within the limits specified in the aircraft flight manual. The aircraft's weight on take-off from Lake Adonis would have been about 4 900 pounds, with a centre of gravity located minus 3.5 inches from datum. The type approval data sheet and the Transport Canada-approved DHC-2 flight manual indicate that the maximum allowable take-off weight is 5 100 pounds for skiplane operation and that the centre of gravity must be between minus 1.25 inches and minus 8.11 inches from datum.

The regulation governing weight and balance control states that an air operator shall specify in its company operations manual its weight and balance system and instructions to employees regarding the preparation and accuracy of weight and balance calculations. The Cargair Ltd. operations manual states that, for bush operation, the company employs ready-to-use forms for calculating weight and balance. The dispatcher ensures that the total load is within the envelope specified on the form for the aircraft in use, and the pilot ensures the load is correctly distributed in the aircraft. The ready-to-use form gives the results of calculations for various

combinations of fuel, passengers, and freight. The form does not, however, in any way indicate where the centre of gravity is located for the various combinations and, contrary to the standard, does not allow the pilot to accurately determine the aircraft's centre of gravity. This irregularity was reported to Cargair Ltd. in a base audit conducted by Transport Canada in 1992. Despite this report, no change was made in the form, which is still part of the company operations manual approved by Transport Canada on 23 October 1999.

Cargair Ltd. holds an air operator certificate under Part VII, Subparts 2 and 3 of the *Canadian Aviation Regulations*. This flight was conducted under Subpart 3, which governs Canadian air operators engaged in single-engine air transport service or aerial operations involving sightseeing operations. The information gathered indicates that, since 1992, Cargair Ltd. has undergone two base audits by Transport Canada but no regulatory audit. According to the *Manual of Regulatory Audits* (TP 8606), every air carrier holding a Canadian Aviation Document will be audited on a periodic cycle ranging from 6 to 36 months. This periodic cycle can be extended to a 60-month maximum in some instances. The National Audit Program was developed by Transport Canada, Civil Aviation to primarily promote conformance with the aviation regulations and standards that collectively prescribe an acceptable level of aviation safety.

A.I.P. Canada stipulates that the need to carry clothing and equipment that will provide protection from insects in summer and exposure in other seasons cannot be overstressed when a flight takes place in sparsely settled areas of Canada. Further, *A Safety Guide for Aircraft Charter Passengers* (TP 7087) recommends wearing appropriate clothing and footwear for the weather conditions in the area being overflown. The investigation determined that some of the passengers were not dressed suitably to protect themselves from long exposure. One of the passengers suffered significant frostbite to the fingers, requiring amputation.

To reduce engine wear, the engine manufacturer recommends using cutback power when climbing. The information gathered indicates that this cutback power climb procedure is normally used by DHC-2 company pilots. A performance analysis by the aircraft manufacturer revealed that the aircraft's rate of climb at 4 900 pounds is 665 feet per minute when using the cutback power climb technique with flaps up, equivalent to a climb gradient of 5 degrees. Using maximum continuous power, the aircraft's rate of climb is 865 feet per minute, a climb gradient of 6 degrees.

The mountain's south-east side where the aircraft crashed has an average slope of about 5 degrees. However, the slope increases gradually to 11 degrees approaching the summit. The escarpment on the opposite side is much steeper, with a slope of about 24 degrees. The regulations concerning VFR flight obstacle clearance requirements state that, except when conducting a take-off or landing, no person shall operate an aeroplane in VFR flight during the day at less than 300 feet above ground level or less than 300 feet horizontally from any obstacle.

In some conditions, pilots' abilities to estimate the size and distance of obstacles in their flight paths can be seriously diminished. Further, if the main obstacle is rugged terrain, the slope may be hard to assess. Pilots can be affected by optical illusions when approaching rising slopes at right angles. When pilots get closer to the ridge, the proximity of the ground tends to hold their attention, creating the illusion of increasing speed to the point where they may be tempted to reduce speed. Pilots may also try to maintain a constant angle between the extended cowl and

the mountain peak by pitching up the aircraft. Consequently, aircraft performance, speed, and vertical separation with the terrain all decrease.

In aviation, the term "stall" means allowing an aircraft to reach a condition of flight where the wings can no longer provide the lift needed to maintain flight. The section of the DHC-2 flight manual dealing with flight characteristics states that the aircraft is easy to fly and manoeuvre until stall. Stall is gentle at all normal load and flap configuration conditions and may be heralded by slight vibration, which increases when the flaps are down. The aircraft pitches up if there is no yawing motion. If yaw is not controlled, the aircraft tends to roll. Prompt corrective action must be initiated to prevent the roll from worsening. The DHC-2 is not equipped with a visible or audible warning device indicating imminent stall.

The DHC-2 was built and certified in accordance with the *British Civil Airworthiness Requirements* published in 1945. When the DHC-2 was certified in the early 1950s, certification requirements were less stringent than they are now. More recent single-engine aircraft are certified in accordance with Part 23 of the United States *Federal Aviation Regulations* (FAR). According to FAR Part 23, aircraft must be equipped with a stall warning system to warn the pilot clearly and distinctly of an approaching stall.

Analysis

Examination of the aircraft did not reveal any engine or aircraft system failure or malfunction. There is no indication that there was an emergency situation or that the aircraft experienced any problems prior to impact. The aircraft's weight and balance were not calculated prior to departure from Lake Adonis, but the aircraft was slightly under the maximum allowable weight and the centre of gravity was within the permitted limits. However, the company's use of a ready-to-use weight and balance form is irregular because the form does not allow the pilot to know the exact position of the centre of gravity. This irregularity was reported to the company in a base audit conducted by Transport Canada in 1992. Since then, no change has been made in the DHC-2's weight and balance control system by Cargair Ltd. The ready-to-use form is still part of the latest company operations manual, which was approved by Transport Canada on 23 October 1999.

Despite the prompt report of the missing aircraft, approximately 4 hours 40 minutes passed before the rescuers arrived at the accident site. Efforts to locate the aircraft were hampered by the broken ELT antenna, which reduced the transmission range of the ELT's signal, and the colour of the aircraft, which was mostly white and blended into the snowy ground.

The accident was survivable because of the minimum damage to the cabin, aft of the two front seats. The passengers were trapped inside the aircraft except for one passenger who managed to get out despite difficulty in moving. The pre-flight safety briefing did not inform passengers where to find the survival equipment on board the aircraft. Had they known, they could have used the sleeping bags to protect themselves from exposure and thereby delay hypothermia. The passengers did not know where the ELT was located and how to use it, however this did not impact on the search and rescue operations in this instance. Nevertheless, it remains important that every passenger know where to find the ELT and how to use it so as not to delay search and rescue operations.

Why the pilot kept the aircraft low over the lake before proceeding towards the rising ground could not be determined. There was nothing preventing the pilot from gaining altitude while flying over Lake Adonis since the aircraft was not overloaded, the cloud layer did not constitute a ceiling, visibility was good, and the engine was functioning normally. The pilot might have maintained his south-westerly direction over Lake Adonis to gain more altitude before heading towards the rising ground. The reason for the decision to head towards the mountain is still undetermined. However, the terrain falls away quickly past the top of the mountain, and this would have afforded the passengers a splendid view of the area.

Low flight in mountainous areas requires great vigilance. Great attention must be paid outside to identify potential obstacles on the route, such as power transmission lines, communication towers, and sometimes even bird activity. There is no indication that the pilot might have been distracted by an untimely event in the cabin or outside before the accident. Special attention must also be paid to the slope of the terrain when approaching a mountain peak. The surrounding terrain may create an optical illusion affecting the perception of the terrain being overflown, leading to underestimation of the slope. The pilot must also ensure that the aircraft has the desired performance to climb the slope at a safe obstacle clearance. The pilot was likely using cutback power to make the climb, thereby considerably reducing the aircraft's climb performance.

When pilots direct their attention outside, their attention to the instrument readings, such as aircraft speed, decreases. Pilots must ceaselessly compare their impressions with the instrument readings. When flying facing the peak, the pilot might have suffered an optical illusion. Despite his experience, the pilot may have underestimated the slope of the terrain and delayed establishing the aircraft's climb when leaving the shore. As the slope steepened approaching the mountain peak, the pilot probably pitched the aircraft up to maintain a constant angle between the extended cowl and the peak. The aircraft's speed would have decreased, further affecting climb performance. Because the aircraft was not equipped with a stall warning system, the pilot might have realized too late that the speed was too low to maintain normal climb performance. Further, the vibration precursory to stalling, as described in the flight manual, would have been minimal because the flaps were up. The pilot's decision to fly at low altitude contributed to putting the aircraft at a reduced distance from the ground and allowed insufficient altitude to recover when the aircraft stalled.

The following TSB Engineering Branch Laboratory Report was completed:

LP 19/00—Lightbulb/GPS/ELT Examination.

Findings as to Causes and Contributing Factors

1. The aircraft probably stalled with insufficient altitude for the pilot to execute a recovery.

2. The prevailing conditions were conducive to optical illusions associated with low-altitude flight over rising terrain.

3. The aircraft was not equipped with a stall warning system, nor was it required by regulation.

4. The pilot's decision to fly at low altitude and probably use cutback power for the climb did not allow for safe obstacle clearance.

5. The pre-flight safety briefing did not inform passengers where to find the survival equipment on board the aircraft. Consequently, they could not use the sleeping bags to protect themselves from exposure and thereby delay hypothermia.

6. Rescue was late because the mostly white aircraft blended into the snowy ground, making it difficult to locate, and the ELT antenna was broken, reducing the range of the signal. Consequently, the survivors' exposure time was increased.

Other Findings

1. The pilot was certified and qualified for the flight.

2. The autopsy and toxicological test results revealed no indication that physiological factors affected the pilot's performance.

3. Records indicate that the aircraft was certified, equipped, and maintained in accordance with existing regulations and approved procedures.

4. The aircraft's weight and centre of gravity were within the limits specified in the aircraft fight manual.

5. There is no indication that there was an emergency situation or that the aircraft experienced problems prior to impact.

6. The ready-to-use weight and balance calculation form is not consistent with the standard. Transport Canada reported this irregularity in 1992, but no change was made in the form, which is still part of the company operations manual approved by Transport Canada on 23 October 1999.

7. The weather conditions were suitable for visual flight.

This report concludes the Transportation Safety Board's investigation into this occurrence. Consequently, the Board authorized the release of this report on 15 November 2000.