AVIATION INVESTIGATION REPORT
A01P0194

COLLISION WITH TERRAIN

WAHKASH CONTRACTING LTD.
DE HAVILLAND DHC-2 C-GVHT
MACKENZIE LAKE, BRITISH COLUMBIA, 4 nm NE
13 AUGUST 2001

Aviation Investigation Report

Collision With Terrain

Wahkash Contracting Ltd.
de Havilland DHC-2 C-GVHT
Mackenzie Lake, British Columbia, 4 nm NE
13 August 2001

Report Number A01P0194

Summary

A de Havilland DHC-2 Beaver floatplane, C-GVHT (serial number 257), took off from Campbell River, British Columbia, at 1530 Pacific daylight time, with a pilot and four passengers on board. The aircraft was on a visual flight rules flight to a logging camp on Mackenzie Sound, 76 nautical miles northwest of Campbell River, and was scheduled to arrive at 1700. When the aircraft arrived over the Mackenzie logging camp, the pilot informed ground personnel by radio that he was overhead at 2800 feet, between cloud layers with no place to descend, and that because of unfavourable weather conditions, he was returning, presumably to Campbell River. The aircraft then flew to a clear area north of the camp and entered the Frederic Creek valley. When company ground personnel could not contact the aircraft by radio, they began a ground search, later followed by an aerial search. The searches were hampered by poor weather. The aircraft wreckage was found three days later, about four nautical miles northeast of the camp. The accident occurred at 1706 in daylight conditions. All occupants were fatally injured, and the aircraft was destroyed. The emergency locator transmitter was destroyed on impact and did not transmit a signal. No fire occurred.

Ce rapport est également disponible en français.

Other Factual Information

The aircraft was owned and operated by Wahkash Contracting Ltd. based in Campbell River, British Columbia, and was normally used to ferry loggers to and from logging camps. The float-equipped aircraft operated only from water surfaces. After departing Campbell River water aerodrome in the afternoon on the day of the accident, the aircraft flew northwest for 43 minutes before making a brief, intermediate stop at a company logging camp at Hoeya in Knight Inlet, 49 nautical miles from Campbell River. After a small consignment of food was offloaded, the aircraft departed Hoeya at 1629 Pacific daylight time[1] and arrived overhead the Mackenzie camp 25 minutes later. The aircraft then continued flying in the area for 12 more minutes, until the accident.

At the time, the ceiling over the camp, which is at sea level, was between 1600 and 1700 feet. It was reported that the north end of the south Frederic Creek valley was free of cloud at the time of the accident but that cloud was moving through a pass into the valley at the south end.

One of the managers of the camp, who was on a logging road in the south valley, advised the pilot to come to the Frederic Creek area because it was clear of cloud. The pilot then flew northeast to Wakeman Sound, where he advised that he could descend below the cloud to the Frederic Creek inlet. The aircraft flew west along Frederic Creek until turning left toward the pass in the south Frederic Creek valley. The pass crosses a north-south divide (saddle); the valley to the east of the divide turns south immediately and descends to Mackenzie Lake. (See Figure 1.)

The pilot was also advised that the ceiling in the pass was between 300 and 400 feet above ground level and that about 1500 feet would be needed to go through the pass. The pilot reported that he was unfamiliar with the area but that he would continue and assess the conditions.

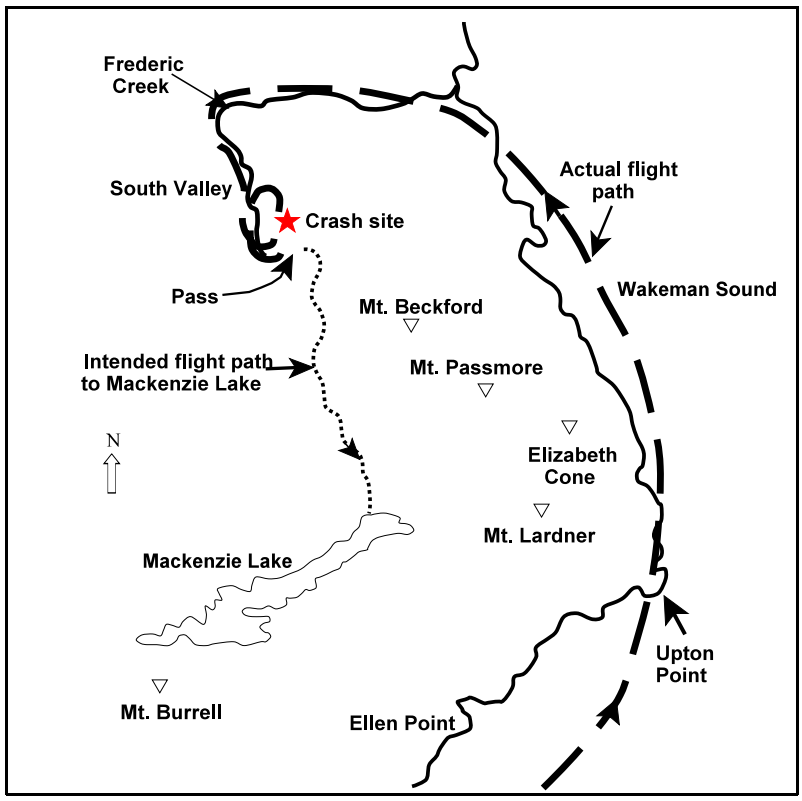

Figure 1 - C-GVHT's flight path

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

The aircraft flew south toward the pass and made one circuit of the valley. After the circuit, the aircraft again flew toward the pass, then executed a sharp left turn about 10 seconds before the accident. The aircraft was flying away from the pass at impact. The last brief radio transmission from the pilot was at 1706, only seconds before impact.

During the second attempt, the turn radius was smaller and the ground speed slower than in the first circuit, allowing the aircraft to come closer to the pass. As a result, the aircraft was forced to turn in a more confined area.

During a level turn, as the angle of bank increases, the stall speed also increases. Table 1 summarizes aircraft stall speeds contained in the Transport Canada–approved DHC-2 Beaver flight manual (PSM 1-2-1). No stall speed information was found for other flap settings. In part, the flight manual warns that, in tight turns, flight load factors may also increase the danger of an unintentional stall. The flight manual advises that it is possible to retain full control of the aircraft at 65 mph with the flaps in the landing position. Flight path data shows that the accident Beaver's ground speed was approximately 70 mph just before the loss of control.

Stall Speed			
		Flap Position	
		Up	Landing
Bank Angle	0°	60 mph	45 mph
	50°	85 mph	
	60°	105 mph	

Table 1 - Stall speeds

The wreckage was found on the east side of the south Frederic Creek valley, about 0.3 nautical mile from the pass near the south end of the valley. The wreckage was found inverted and heading south, at the base of two large trees at the 1100-foot level in a heavily treed area. Most of the damage to the trees at the accident site occurred to the northern exposures of two large trees, which were 25 feet apart and about 120 feet tall. These trees had scrape marks and wing-paint transfer down the lower 60 feet of the trunks. None of the trees in the area surrounding the wreckage had any recent broken branches or broken treetops.

Although the aircraft was extensively damaged, all aircraft components and flight control surfaces were found at the accident site. All seats had broken away from their mounting points on the cabin floor. The emergency locator transmitter had detached from the bracket on the inside wall of the fuselage. The left control wheel of the dual control column had both horns broken off; the right control wheel remained intact. The forward fuel tank had ruptured at impact and was found empty; the inside of the cabin beneath the tank smelled strongly of fuel. A significant amount of clean blue fuel was found in the centre and aft tanks. A cargo net was found stowed in its bag in the cabin—it had not been used to secure 300 pounds of cargo, nor was any other means of securing the cargo found. The cargo had moved forward into the area of the cabin.

Damage to the aircraft is consistent with high deceleration forces and an inverted attitude at impact; such forces exceed human tolerance. The accident was not survivable.

C-GVHT was equipped with EDO 4930 floats and was manufactured in 1951; total airframe time at the time of the accident was approximately 11 325 hours. The most recent mechanical inspection was completed at 11 207 hours on 27 June 2001, 47 days before the accident. Logbooks and maintenance records indicate that the aircraft had been certificated, equipped, and maintained in accordance with existing regulations and approved procedures. In March 1998, a cabin extension kit (supplemental type approval SA90-2, configuration 3) was installed on the aircraft. This kit included the installation of an Alaska cargo door, which significantly increased the volume of the original Beaver baggage compartment. Installation of the larger cargo door made it easier to load bulky cargo into the baggage compartment and changed the moment arm of the cargo compartment from 94 to 97 inches aft of the datum. The floor loading limit remained unchanged.

No indication of any pre-existing airframe defect, engine malfunction, or system deficiency was found. The propeller blades exhibited damage consistent with an engine delivering power at impact. Continuity of the

flight controls was established. The flap actuating cylinder was found extended to a position that corresponds to the 35° setting, which is the take-off position. This flap position is often used in slow flight.

Flight in accordance with visual flight rules (VFR) require pilots to maintain visual reference to the surface and remain clear of cloud.[2] VFR flight above cloud (VFR over-the-top) is permitted, provided that certain conditions are met in accordance with *Canadian Aviation Regulations* (CARs), including weather minima, aircraft equipment, and pilot qualifications.[3]

The pilot held a valid Canadian private pilot licence—aeroplane, issued by Transport Canada (TC). The pilot did not hold an instrument rating or a VFR over-the-top rating. Records show that as of August 2000, he had accumulated more than 4000 hours' total flying time. The aircraft journey log indicated that his first flight to the Mackenzie logging camp was on 01 June 2001, 73 days before the accident, and that he had flown there 21 times since. It was reported that the pilot had flown above the cloud on an earlier flight on the day of the accident.

The maximum certificated all-up weight (MAUW) of the DHC-2 Beaver on floats is 5090 pounds, with an aft centre of gravity (CG) limit of 6.1 inches aft of the datum. In comparison, the MAUW of the Beaver on wheels is 5100 pounds, but the aft CG limit is 8.8 inches aft of the datum.

TC records show that C-GVHT was last weighed on 13 March 1998, at which time the aircraft empty weight was calculated to have been 3550 pounds, with a CG of 2.41 inches forward of the datum. The aircraft was previously weighed on 20 August 1988, at which time the aircraft empty weight was calculated to have been 3275 pounds, with a CG of 0.31 inch aft of the datum. This calculation had been based on a previous weight and balance revision, dated July 1986, which showed that the aircraft was 3317 pounds, with a CG of 0.9 inch forward of the datum. A TSB review of this calculation reveals that the CG figure is erroneous and is 1.8 inches too far forward—that is, it should have been 0.9 inch aft of the datum. The current aircraft journey log recorded the empty weight as 3275 pounds—that is, 275 pounds underweight. This figure was apparently used by the pilot. It is unknown which CG the pilot used.

To provide pilots with accurate weight and balance information for their aircraft, CARs require that the most recent weight and balance document be kept on board an aircraft. A weight and balance document for C-GVHT was found with the aircraft journey log on board. However, the document had been prepared in July 1986 and showed an empty weight of 3317 pounds, with a CG of 0.09 inch forward of the datum. A TSB review of this calculation reveals that the CG figure is erroneous and is 1 inch too far forward. (Note: This CG figure differs from the one used in the revision of August 1988 mentioned previously.) Furthermore, a plastic-laminated load sheet, dated 18 June 1978, that was used by pilots to quickly calculate acceptable aircraft loading, was also kept with the aircraft journey log and showed an aircraft empty weight of 3388 pounds, but without a CG figure.

Section RAC 3-2 of TC's *Aeronautical Information Publication* (AIP) (TP2300) advises that actual passenger weights should be used to determine the weight and balance of an aircraft, but in the event that individual weights are not available, an average passenger weight may be used. AIP prescribes that the standard average weight for adult male passengers is 182 pounds (summer) and 188 pounds (winter).[4]

---

[2] CAR 602.115.

[3] CARs 401.06, 401.44, 602.116, 605.14, and 605.15.

[4] Average weights for women and children are significantly less, whereas the average weight for large males is not less than 215 pounds.

The laminated load sheet found on board the aircraft uses a standard weight for an adult passenger of 165 pounds. The aircraft journey logs record that 165 pounds was being consistently used as the average weight for an adult passenger. Actual total weight of the pilot and the passengers on the accident flight was calculated to have been 1010 pounds— 185 pounds greater than the estimated weight using the company's standard weight of 165 pounds and 100 pounds greater than the calculation using the correct standard weight figure. TSB reviewed the company's pilot daily log sheets for the weeks before the accident and calculated that numerous flights were overweight. Many of the weight figures from these daily log sheets differed remarkably from those recorded in the aircraft journey log for the same flight, and weight of the cargo carried was often recorded lower in the journey log.

The pilot loaded the aircraft at Campbell River himself, as was his practice. There is no information that the cargo or passengers were weighed before the flight. Weight and balance calculations by TSB, using actual weights of the occupants and cargo carried, show that, at take-off from Campbell River, the aircraft was 5364 pounds, with a CG of 8.7 inches aft of the datum—274 pounds over MAUW and 2.6 inches outside the aft CG limit. Calculations also showed that the aircraft was overloaded by approximately 59 pounds at the time of the accident and that the CG was 1.6 inches outside the aft limit. (See Figure 2. Note that this graph also shows the aft CG limit for the wheels configuration.)

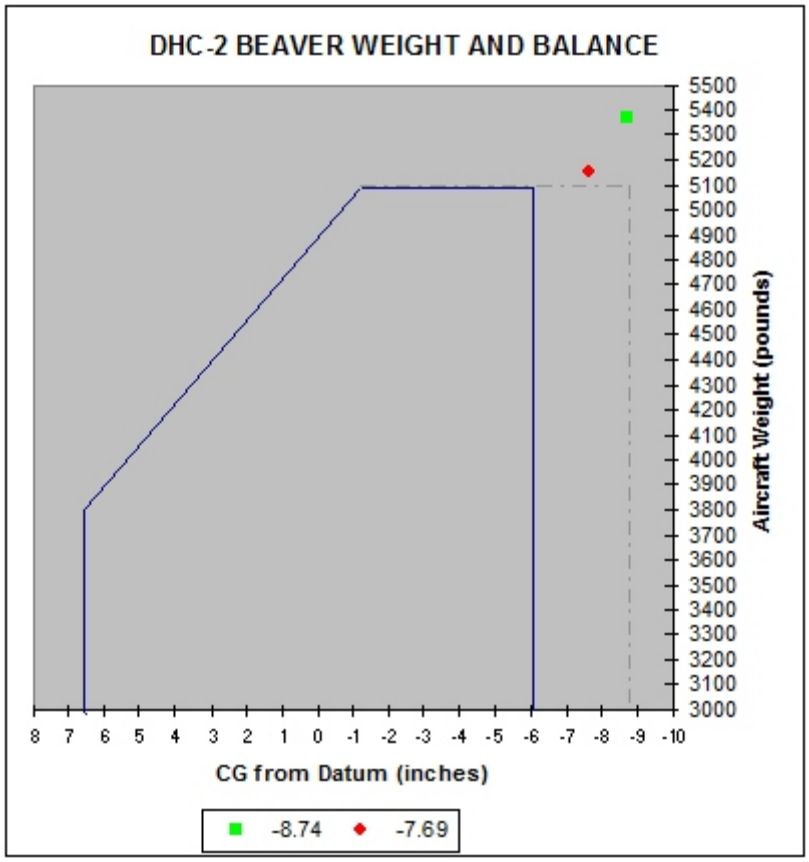

Figure 2: Weight and balance calculations for C-GVHT

The DHC-2 Beaver has known stall characteristics when loaded at the aft CG limit. Since the accident aircraft was loaded over the maximum allowable weight and outside the aft CG limit, the stall characteristics were unproven. However, the following information gives valuable insight into the possibilities:[5]

> The DHC-2 aircraft was designed and certified to meet British Civil Airworthiness Requirements, published in 1945. At that time, the British Air Registration Board's policy was that "tests to prove compliance . . . need only be made at such points in each range as are necessary for reliable inferences to

[5] TSB Report A98P0194, pp. 4–5. (Released 06 July 2000)

be made of the behaviour of the aeroplane over the remainder of that range".

In part, the specific certification requirements regarding aircraft stall characteristics state that "as the stall is approached from straight flight, there shall be no violent wing dropping and no tendency to spin" and "the aeroplane should give, by juddering or other means, clear warning of the approach to the stall from straight or turning flight".

In the case of the DHC-2, the aircraft is not equipped with any aural or visual stall warning system, and warning of an impending stall is dependant on juddering or on some other aerodynamic indication.

Washington-based Aeronautical Testing Service Inc. (ATS) is an aeronautical consulting and manufacturing company involved primarily in the engineering, development, and manufacture of modifications for general aviation aircraft. According to company literature, ATS was created to help increase the safety and performance of general aviation aircraft by designing and building vortex generator kits for use on a variety of general aviation and agricultural aircraft. ATS completed flight tests on an un-modified DHC-2 MKI aircraft as part of a vortex generator design for that aircraft type. These tests evaluated the stall characteristics, stall warning, and controllability of the stall in a variety of weight and balance configurations that were not specifically required by the original British Civil Airworthiness Requirements.

The flight test report of that activity indicates that with a forward CG, the stall characteristics of the aircraft were acceptable. However, with an aft CG and with power on, departures of 60 degrees of roll, 30 to 40 degrees of yaw, and 30 degrees of pitch were reported as being common during these flight tests. With the flaps selected to the "climb", "take-off", and "landing" positions, the ATS flight test report indicates that the ailerons and rudder were effective up to the point of the stall but were not adequate to control the violent roll and yaw once the stall occurred. A positive elevator movement was required to recover from the stalled condition before the aircraft began to spin. Test pilots with the TC Flight Certification Branch and with de Havilland have not experienced such violent stall characteristics as described by both ATS and by the accident pilot involved. The TC Aircraft Certification Branch subsequently indicated that it will examine the DHC-2 service history and stall characteristics to determine whether any mandatory changes are warranted.

On 24 January 2001 TC completed a review of some 200 TSB and 89 National Transportation Safety Board (NTSB) occurrence reports of Beaver incidents. There were 13 TSB and 8 NTSB occurrences that were suspected of being related to wing stalls. It was further determined that there were no other reports which clearly demonstrated a stall occurring at or above 80 mph, as stated in report A98P0194. A stall warning device is not required on the DHC-2 Beaver as part of its certification, and review of its service history data indicates that aircraft safety has not been adversely affected so as to warrant mandatory corrective action.

Analysis

No mechanical conditions were identified as contributing to this accident. This analysis therefore focuses on operational factors surrounding the flight.

Wreckage damage characteristics, damage found to two trees at the accident site, and the lack of damage to surrounding trees indicate that the aircraft followed a steep, nose-down flight path seconds before impact. The aircraft struck the trees and came to rest inverted; it likely rolled inverted when the pilot lost control.

The pilot had declared that he intended to assess the weather in the pass at the end of the south Frederic Creek valley. The rising terrain and the cloud base near the pass limited the height above ground that the aircraft could fly and remain clear of cloud. The available manoeuvring area was also confined by the narrowing of the valley toward the south end. Although the valley was oriented predominately north-south, the pass at the south end of the valley had to be crossed in an east-west direction, making it impossible for a pilot to see through the pass until the aircraft was in it.

The accident occurred after a left turn away from the pass, during the second attempt to get through the pass. During this attempt, the turn radius was smaller and the speed slower than in the first circuit, allowing the aircraft to come closer to the pass. It is therefore most likely that during the second attempt to investigate the pass, the pilot slowed the aircraft and, when he decided to abort flight through the pass, turned sharply to avoid the higher terrain on the north side. As a result, the pilot was forced to turn left in a more confined area and would have applied greater bank angle in the turn to avoid the steep terrain.

The aircraft weight and balance were outside the approved and tested flight envelope, in an area where the stall characteristics of this aircraft are unproven. The aircraft weight exceeded the certificated MAUW, and the CG was outside the floatplane aft limit, the latter being a condition known to hasten the onset of stall, produce challenging aircraft attitude changes, and make recovery difficult. Furthermore, because incorrect values were used for the aircraft basic weight and passenger weight (errors of 275 and 185 pounds respectively), any weight and balance calculation would consistently have been approximately 450 pounds less than actual.

During a turn in level flight, as the angle of bank increases, stall speed also increases. The steep and rapid turn in slow flight would have caused the Beaver to stall. The out-of-limit weight and balance condition aggravated the aircraft's response to the evasive manoeuvre and presented the pilot with an abrupt attitude change from which he could not recover before losing control of the aircraft and striking the trees. The stall and the subsequent loss of control occurred only seconds before impact.

The Alaska cargo door installation increased the volume of the cargo compartment. This increase was conducive to larger loads being stowed farther aft, resulting in possible overloading of the cargo compartment. Unrestrained cargo likely shifted during this manoeuvring and exacerbated the out-of-limit CG, making control even more difficult. In addition, heavier cargo items would have been free to migrate during the impact sequence and become projectiles, increasing the level of injury to the occupants. However, the impact forces alone were not survivable.

Findings as to Causes and Contributing Factors

1. The pilot abandoned his attempt to fly through the pass because of unsuitable weather conditions. He flew into a confined area that required him to manoeuvre the aircraft aggressively to avoid the rising terrain, causing the aircraft to stall.

2. The aircraft weight exceeded the certificated MAUW, and the CG was outside the floatplane aft limit. The out-of-limit weight and balance aggravated aerodynamic stall and produced rapid and uncontrolled aircraft attitudes from which the pilot could not recover before striking the trees.

3. Basic weight and balance of the aircraft was incorrectly recorded in several aircraft documents, leading to remarkable discrepancies in take-off weight and CG calculations. As a result, a pilot could not calculate an accurate weight and balance. In certain conditions, calculations erroneously showed that the aircraft was below maximum allowable gross weight.

Findings as to Risk

1. The practice of using a non-standard passenger weight led to inaccurate take-off weight calculations and provided aan estimated total passenger weight that was 185 pounds less than actual.

2. Weight and balance calculations performed using inaccurate figures would not have revealed that the aircraft was overloaded until it was approximately 450 pounds beyond the maximum limit.

3. Aircraft weight exceeded the maximum allowable gross weight, and the CG was outside the aft CG limit. This weight and balance combination placed the aircraft outside the manufacturer's original design envelope, to where slow speed and stall handling characteristics are neither proven nor certificated.

4. Cargo was not secured by the available cargo restraint and might have shifted during aircraft manoeuvring. Such cargo movement would have exacerbated the effects of the existing aft CG and likely increased the level of injury to the occupants.

Other Findings

1. The pilot chose to fly above cloud in accordance with the visual flight rules and could not descend through the cloud at his intended landing site.

2. The Alaska cargo door installation increases the volume of the cargo compartment. The installation is thereby conducive to larger loads being stowed farther aft and possible overloading of the cargo compartment.

3. The DHC-2 Beaver is not equipped with an aural or visual stall warning system, nor is it required by regulation. Warning of an impending stall is dependent on juddering or some other aerodynamic indication.

This report concludes the Transportation Safety Board's investigation into this occurrence. Consequently, the Board authorized the release of this report on 24 October 2002.