Transportation Safety Board of Canada

Bureau de la sécurité des transports du Canada

AVIATION INVESTIGATION REPORT

A03O0088

STALL/SPIN AND COLLISION WITH TERRAIN

FOUND AIRCRAFT CANADA INC.

FBA-2C1 BUSH HAWK C-GTUP

LAKE TEMAGAMI, ONTARIO

07 APRIL 2003

Canada

The Transportation Safety Board of Canada (TSB) investigated this occurrence for the purpose of advancing transportation safety. It is not the function of the Board to assign fault or determine civil or criminal liability.

Aviation Investigation Report

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Summary

The aircraft, a Found Aircraft Canada Inc. FBA-2C1 Bush Hawk XP aircraft (registration C-GTUP, serial number 37) was being operated from a cleared ice-strip, approximately 1600 feet long and 50 feet wide, at 46˚57.8'N, 080˚01.3'W, on the frozen surface of Lake Temagami, 20 kilometres southwest of the town of Temagami, Ontario. On Monday, 07 April 2003, the pilot took off on a visual flight rules (VFR) flight to Parry Sound, Ontario; the take-off heading was approximately 010°M. The aircraft lifted off approximately half-way down the strip, climbed on runway heading to 200-300 feet above the lake surface, then commenced an approximately 30° bank turn to the left. After the aircraft had turned approximately 120°, the aircraft rolled about 90° to the left, the nose dropped, and the aircraft stalled and entered an incipient spin to the left. The spin stopped after about one turn, then the aircraft rotated briefly in the opposite direction and struck the frozen lake surface in a near-vertical attitude. The accident occurred at approximately 0910 eastern daylight time. The aircraft was destroyed and both occupants were fatally injured.

Ce rapport est également disponible en français.

Other Factual Information

The pilot held an airline transport pilot licence valid for single- and multi-engine aircraft, land and sea, a Class 1 instructor rating, and a Group 1 instrument rating. His medical certificate had a limitation that glasses must be available. According to medical records, he had accumulated approximately 2800 hours total flying time. He had also accumulated approximately 30 hours on the aircraft type.

The passenger was a licensed pilot holding a commercial pilot licence valid for single-engine aircraft, land and sea, and whose medical certificate had a limitation that glasses or contact lenses must be worn. According to records, the passenger had accumulated approximately 200 hours total flying time, none on this aircraft type.

Autopsy results indicated that both occupants died of multiple injuries sustained on impact. No pre-existing conditions were identified that were likely to have contributed to death. Both occupants had similar injuries to the extremities that indicated both were attempting to regain control of the aircraft at impact. Toxicological examination indicated nothing remarkable on either person.

The FBA-2C1 aircraft type is certified in the normal category under type certificate A-67. C-GTUP was built in 2002. It was equipped with a 300 HP Lycoming IO-540-L1C5 engine and a three-bladed Hartzell HC-C3YR-1RF/F8068 constant-speed propeller. The aircraft was built with a wing that incorporated Fowler flaps in accordance with supplemental type certificate (STC) SA01-105, providing a maximum take-off weight of 3500 pounds. It had a valid Certificate of Airworthiness issued 04 February 2003 and was delivered on 07 February 2003 in a wheel configuration with standard tires.

Records indicate that the aircraft had been maintained in accordance with regulations. On 03 April 2003, at North Bay, tundra tires[1] were installed on the aircraft. On Friday, 04 April 2003, the aircraft was flown to Lake Temagami, the last flight before the accident. Total airframe time was 35 hours.

The aircraft was parked outside in front of the pilot's residence[2] adjacent to the south end of the airstrip from Friday afternoon until the morning of the accident. Wing covers were available for the aircraft but likely were not installed. Snow fell throughout the day on Saturday. The weather on Sunday night and Monday morning was clear, with an overnight temperature below -20°C and reports of overnight frost. On the morning of the occurrence, there was a wind of 5-10 knots from the northeast. Based on nearby airport reports, the temperature rose to between -15°C and -10°C by the time of the accident.

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1 The tundra tires are listed in the type certificate data sheet as optional equipment with a gross weight limit of 3200 pounds.

2 Fuel was available at this location but it could not be determined how much fuel was taken on.

At about 0800[3] on Monday, the pilot taxied the aircraft to the rear of the residence for pre-flight preparation and refuelling. He returned to the front sometime before 0830 where he parked the aircraft until about 0900, when he and his passenger boarded the aircraft for the flight. There were ladders and brooms, which the pilot was known to have used on other occasions to sweep snow and frost off the aircraft, available at the refuelling location. No de-icing fluids were available. Based on observation two days later, direct sunlight did not reach the spot where the aircraft had been parked until 0900 and would not have had time to melt the frost, if any had been present.

The flight path of the aircraft is presented at Figure 1. The runway and initial climb path were sheltered by trees on the right. As the aircraft emerged above the height of the trees during the climb, it was increasingly exposed to the wind from the northeast. When the aircraft turned to the left, the wind changed from a quartering head-wind to a tail-wind. The Transport Canada Flight Instructor Guide[4] describes a number of illusions that can be created by drift of an aircraft in low-level flight. Specifically, a turn from headwind to downwind produces an illusion of a slip inwards followed by an illusion of increased airspeed.

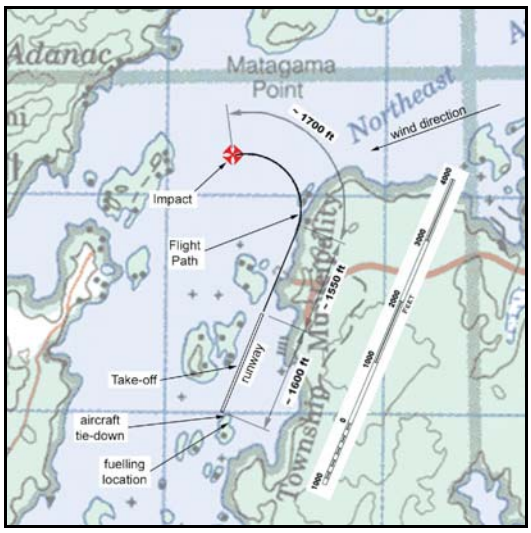

Figure 1. Accident Site

The normal take-off procedure according to the *Pilot's Operating Handbook* (POH)[5] is to set the flap at 10°, lift the tail wheel at 45 KIAS, and climb at 70 to 80 KIAS. At these speeds, the time from lift-off to departure from controlled flight was calculated to be between 32 and 40 seconds, angle of bank in the turn was calculated to be between 26° and 32°, and, based on manufacturer's performance figures, the aircraft would have reached a height of 400 to 500 feet above ground (agl). The flaps would normally be retracted after the aircraft reached a safe speed and altitude; it is not known when the flaps were retracted. The expected stall speed in the turn according to the POH was approximately 60 KIAS.

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3 All times are eastern daylight time (Coordinated Universal Time minus four hours) unless otherwise noted.

4 Transport Canada TP 975E, Flight Instructor Guide, February 2000, Exercise 20 – Illusions Created by Drift – Low Flying.

5 Pilot's Operating Handbook - FBA-2C1 Bush Hawk 300 HP, Found Aircraft Canada Inc. p/n FAC2-M300, dated November 10, 2000, including Supplement 2, Tundra Tires, and Supplement 3, Bush Hawk-SP with Slotted Fowler-type Flap.

Investigators reached the accident site at approximately 1800 on the day of the occurrence, and there was no frost observed on the aircraft. During the day, the temperature had been 1 to 2 degrees below zero and there were clear skies and bright sunlight. The wreckage was in unobstructed sunlight, and any frost that was on the aircraft would have disappeared during the day.

It was determined that the aircraft was intact when it struck the ice; no pre-impact structural or control anomalies were identified. Control cables were attached and continuous to the cockpit; control surfaces were all attached and free to move through their full range of travel. Elevator trim was slightly aircraft-nose-up, not inconsistent with this phase of flight. The flaps, which are electrically operated via a jack screw, were up at impact. The engine and propeller both showed signs of rotation, indicating that the engine was producing power at the time of the impact. Cockpit instruments did not yield any useful information.

The fuel tanks, which were integral to the wings, were compromised at impact and although there were indications of fuel on the ice, it was not possible to determine the fuel quantity on board the aircraft. Some loose cargo, including the aircraft skis, was found in the wreckage. The size and placement of the skis in the aircraft left minimal room for them to shift in flight, and the rear bulkhead showed no signs of having been struck by the skis sliding aft. The remaining cargo was unlikely to have moved significantly because it probably would have been restrained by friction and interference with the skis.

Based on a full load of fuel and the most unfavourable location of materials found in the wreckage, the gross weight of the aircraft at the time of the accident was calculated to be approximately 3200 pounds and the centre of gravity was within limits. The aircraft was not equipped with a flight data or cockpit voice recorder, nor was either required by regulation.

The Found FBA-2C1 is equipped with a vane-type stall warning unit in the leading edge of the right wing. The unit is designed to activate an audible warning and a light between 5 and 10 knots above the stall in all configurations. The wing section is NACA 23016[6] inboard and NACA 23012 outboard. The certification flight test program found the aircraft type to be compliant with CAR 523 requirements for stall characteristics. In level-flight stalls, it was possible to prevent more than 15° of roll or yaw through normal use of the controls. In turning stalls, entered from a co-ordinated 30° bank turn, the aircraft tended to roll wings-level. A review of the service history of the type revealed no controllability issues related to this occurrence.

C-GTUP was delivered in a standard wheel configuration. Production flight tests, during January 2003, verified that its stall characteristics were representative of type and that the stall warning system functioned at the correct airspeed. There was no information as to the aircraft having been stalled in a wheel configuration since delivery. During February 2003, stalls were

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[6] This wing section is one of the five-digit series of airfoil sections developed by the United States National Advisory Committee for Aeronautics (NACA) during the 1930s. The NACA 23012 and 23016 wing sections are basically similar in shape except for thickness: the 23012 has a maximum thickness of 12% of chord while the 23016 is 16%.

carried out on skis to obtain a limited supplemental type certificate for the installation. A tendency for the right wing to drop at the stall was attributed to the ski installation. The skis were subsequently removed and the approved tundra tires installed.

The Found FBA-2C1 is not certified for flight in known icing. The POH requires that even small amounts of frost, ice, or snow be removed from the aircraft before take-off because their effect on performance and handling. Canadian Aviation Regulation (CAR) 602.11 prohibits take-off with frost, ice, or snow adhering to any critical surface.

The detrimental effect of contamination on aircraft critical surfaces is well documented. The Aeronautical Information Publication (AIP) Canada states the following with respect to frost, ice, and snow contamination on the ground[7]:

> The degradation in aircraft performance and changes in flight characteristics when frozen contaminants are present are wide-ranging and unpredictable.
>
> Test data indicate that frost, ice or snow formations having a thickness and surface roughness similar to medium or coarse sandpaper on the leading edge and upper surface of the wing can reduce lift by as much as 30%, and increase drag by 40%... A significant part of the loss of lift can be attributed to leading edge contamination. The changes in lift and drag significantly increase stall speed, reduce controllability, and alter aircraft flight characteristics. Thicker or rougher frozen contaminants can have increasing effects on lift, drag, stall speed, stability and control.

The AIP states in Air 2.12.3, Aircraft Contamination in Flight – Inflight Airframe Icing, that ice accretion may result in increased stall speed and reduced stall angle of attack and, therefore, an aerodynamic stall can occur before the stall warning systems activate. An FAA Advisory Circular[8] on icing contains almost identical language and also notes that on some airfoils, surface roughness on the afterbody of a wing can have an effect as great as leading edge roughness.

There have been several accidents involving Cessna 208 Caravan aircraft, which also use a NACA 230 series airfoil, in which a stall after take-off was attributed to wing contamination. In one non-fatal accident, it is known that the stall warning system did not activate before the aircraft stalled[9]. A recent U.S. National Transportation Safety Board advisory[10] cited another

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7 Aeronautical Information Publication Canada, Section AIR 2.12.2, Aircraft Contamination on the Ground – Frost, Ice or Snow.

8 FAA Advisory Circular 20-117, Hazards Following Ground Deicing and Ground Operations in Conditions Conducive to Aircraft Icing, dated 17 December 1982, re-issued 29 March 1988

9 Transportation Safety Board of Canada report A99P0181, Loss of Control, Cessna 208 Caravan Amphibian C-FGGG, Abbotsford Airport, British Columbia, 28 December 1999.

10 NTSB Advisory, Alert to Pilots: Wing Upper Surface Ice Accumulation, 29 December 2004.

recent Cessna Caravan take-off accident. The advisory expressed concern that, although the performance degradation associated with visible ice accretion is well understood, it was apparent that many pilots did not recognize the effect that *fine particles of frost or ice, the size of a grain of table salt and distributed as sparsely as one per square centimetre over a wing's upper surface*, can have. This frost or ice can result in the following:

- severe performance penalties;
- aerodynamic degradation as severe as that caused by much larger and more visible ice formations such as *dramatic* double horn accretion; and,
- small patches of almost imperceptible frost can result in localized asymmetrical stalls on the wing which can result in roll control difficulty.

Contamination on the wing may cause the wing-tip to stall before the wing root, resulting in loss of aileron control. Usually, without contamination, the wing root stalls first; therefore, the aileron remains effective at the stall and contributes to achievement of roll control requirements for certification.

There have been several wind tunnel studies of the effect of icing on NACA 230 series airfoils. One such study measured the effect of frost on a NACA 23012 wing section[11]. The frost-contaminated wing suffered a 19% loss of maximum lift coefficient, slightly greater than the lift loss of an ice-contaminated wing, and a 4.5° reduction in the stall angle of attack. A second test, after some of the frost had sublimated, showed a 9% loss of maximum lift coefficient and a 3.4° reduction in the stall angle of attack. In the frost tests, the wing also displayed an unstable trend in wing-only pitch moment coefficient.

Analysis

This accident occurred when the aircraft stalled and spun at an altitude too low to permit recovery. The spin was arrested within one turn and both occupants had their hands on the controls at impact, indicating that pilot incapacitation was not a factor. The investigation focussed on understanding the factors that, together, contributed to the aircraft stalling without the pilot taking corrective action, dropping a wing in a manner uncharacteristic of the aircraft type as certified, and entering a spin.

There were no direct indications, such as a witness observation, of frost on the wing of the aircraft prior to the occurrence. It is not known if the pilot observed any frost and if so what he did to remove it. The recent NTSB safety advisory notes that "almost imperceptible" amounts of frost can have a catastrophic effect on aerodynamic performance. It also acknowledges that there are circumstances that make it difficult to perceive the presence of contamination, and it

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[11] Transport Canada TP 13925E, Full Scale Wind-Tunnel Simulation of Take-Off Performance Degradation with Contaminated Fluid Runback, April 2002.

offers an insight into pilots discounting the significance of amounts of frost that are much less than they have seen accumulated in flight on aircraft that subsequently landed without apparent difficulty.

In this occurrence, there is nothing to indicate that the pilot did not carry out a normal pre-flight inspection, nor to indicate that he did not remove surface contamination before flight. If the pilot used the available broom to remove frost, it is possible that some amount of frost residue remained on the aircraft, since a broom is not likely to remove all frost adhering to the metal surface. It also cannot be ruled out that frost was present but undetected on some parts of the wing despite the pre-flight inspection.

Frost contamination of the wing upper surface would cause the loss of approximately 19% of maximum lift coefficient, which would result in the stall speed in the turn being approximately 67 KIAS rather than 60 KIAS. Increased drag caused by frost contamination would result in a reduced rate of climb, explaining why the aircraft reached 200 to 300 feet when calculations show the aircraft should have reached 400 to 500 feet agl. The aircraft's stall warning system, with an audio and visual warning, should have activated 5-10 knots above the normal stall speed. As the pilots apparently did not react to recover from a stall warning and impending stall, it could be surmised that the stall warning did not activate before the aircraft stalled, indicating that the aircraft stalled before its speed reduced to 65-70 KIAS. Frost on the wings would result in a higher than normal stall speed and also inhibit normal impending stall indications such as buffet. When the aircraft stalled, it entered a spin, uncharacteristic of this airplane. Frost on the wings would explain the loss of control and abnormal after-stall characteristics of the aircraft. There had been frost during the previous night, and although no one apparently saw frost on the aircraft lifting surfaces before or after the accident, there is no plausible condition other than frost contamination that would explain this accident. It is therefore concluded that there was frost on the aircraft's lifting surfaces when the aircraft took off.

The normal climb speed for the aircraft was 70 to 80 KIAS; therefore, factors that likely contributed to the aircraft slowing down were examined. During the turn, the aircraft experienced a tail wind that was increasing with height, resulting in a negative performance wind shear, which tended to reduce the airspeed. The presence of frost on the wing would create greater than normal drag and contribute to the aircraft slowing and not gaining as much height as predicted by the POH. The aircraft height was lower than normal for a turn after take-off, and, as a result of the turn to downwind, there may have been an illusion of increasing speed that masked a decrease in airspeed.

The higher angle of attack required to produce lift with a contaminated wing would result in the pitch attitude being similar to that of a normal climb, further masking the perception of performance loss. Reduced longitudinal stability due to frost on the wing would reduce the nose-down pitch tendency normally associated with reducing airspeed, removing a further cue to the pilot. If 10° of flap was used for take-off in accordance with the POH, flap retraction would create a nose-up pitching moment and reduce the margin to the stall. Each of these factors by itself is minor, but they are all negative in their influence on the speed of the aircraft and on the pilot's ability to discern a speed reduction. Together, the factors contributed to the aircraft speed decreasing, unnoticed, to the point of stall.

Findings as to Causes and Contributing Factors

1. There was frost contamination on the upper surface of the wing that was either undetected or incompletely removed, degrading the aerodynamic performance of the wing, resulting in a stall without warning, at higher-than-normal airspeed.

2. The combined effects of illusion of higher than actual airspeed during a low-altitude turn to downwind and reduced longitudinal stability due to frost on the wing negated usual cues that would alert the pilot to the slow speed. As a result, the pilot was likely unaware that the aircraft was slowing down.

3. The aircraft stalled and entered a spin at a height too low to permit recovery.

This report concludes the Transportation Safety Board's investigation into this occurrence. Consequently, the Board authorized the release of this report on 31 May 2005.

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