Transportation Safety Board of Canada

Bureau de la sécurité des transports du Canada

AVIATION INVESTIGATION REPORT A09C0017

COLLISION WITH TERRAIN AT TAKE-OFF

TRANSWEST AIR LIMITED
DE HAVILLAND DHC-6 SERIES 100, C-FCCE
LA RONGE, SASKATCHEWAN
04 FEBRUARY 2009

Canada

Aviation Investigation Report

Collision with Terrain at Take-off

Transwest Air Limited
De Havilland DHC-6 Series 100, C-FCCE
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Summary

The Transwest Air Limited spring ski-equipped De Havilland DHC-6 Series 100 (registration C-FCCE, serial number 8) was taking off from a ski strip east of and parallel to Runway 36 at La Ronge, Saskatchewan. After the nose ski cleared the snow, the left wing rose and the aircraft veered to the right and the captain, who was the pilot flying, continued the take-off. The right ski, however, was still in contact with the snow. The aircraft became airborne briefly as it cleared a deep gully to the right of the runway. The aircraft remained in a steep right bank and the right wing contacted the snow-covered ground. The aircraft flew through a chain link fence and, at approximately 0915 central standard time, crashed into trees surrounding the airport. The five passengers and two crewmembers evacuated the aircraft with minor injuries. There was a small fire near the right engine exhaust that was immediately extinguished by the crew.

Ce rapport est également disponible en français.

Other Factual Information

The 0900 [1] weather reported at La Ronge was as follows: wind 180° true at 4 knots, visibility 15 statute miles (sm), scattered cloud at 12 000 feet above ground level (agl), broken cloud at 25 000 feet agl, temperature -10ºC, dew point -12°C, and altimeter setting 29.55 inches of mercury. The aircraft had been parked outside on snow for several days. From the time it was last flown on 29 January 2009, there were periods of snow each day until the day of the accident flight. On January 31, afternoon temperatures were at or above 0°C. [2]

The ski strip was located on the east side of and parallel to Runway 18/36 of the La Ronge Airport. As the strip was not maintained by the airport operator, its use was solely at the discretion of ski-equipped operators. The surface of the ski strip consisted of well-packed snow covered by a layer of fresh unpacked snow of approximately three to four inches in depth. The snow on the side of the ski strip was soft. A tree line topped at approximately 90 feet agl was located about 350 feet to the east of the ski strip.

The captain, who was the pilot flying, held a valid commercial pilot licence and a current pilot proficiency check for the DHC-6. He had in excess of 14 000 hours total flying time and more than 11 000 hours on the DHC-6 (including over 1000 hours of ski experience), most of which was as pilot-in-command. Company records indicate that he had completed ski configuration training in December 2008. He had completed ground icing training in January 2009. The captain had worked two days of the last seven, accumulating 5.2 hours of flying time. He had not flown on the day prior to the accident.

The first officer was the pilot not flying and held a valid commercial pilot licence and a current pilot proficiency check for the DHC-6. He had about 625 hours of total flying time with approximately 425 hours on the DHC-6 as a first officer. His experience on skis was limited to one previous flight. Company records indicate that he had completed recurrent flight training in January 2009, this being his sole flying day in the previous seven days, as well as ground icing training in January 2009.

Ground icing training consisted of using materials available from Transport Canada's "When in Doubt... Small and Large Aircraft - Aircraft Critical Surface Contamination Training for Aircrew and Groundcrew" (TP 10643). Both crewmembers had completed a written exam based on the questions contained in Chapter 6 of that manual.

The weight and centre of gravity of the aircraft were within the prescribed limits. The take-off weight was approximately 11 000 pounds.

The first officer reported for duty at 0800, about one hour prior to departure, to prepare the aircraft. He completed the external inspection and set up pre-heat for the engines and passenger compartment. During the external inspection, the first officer used a stepladder of sufficient

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1 All times are central standard time (Coordinated Universal Time minus six hours).

2 Historical weather data obtained from Environment Canada's National Climate Archive.

height to inspect the wings and to brush off the accumulated snow. The horizontal stabilizer appeared clear of snow and was not brushed. The captain then arrived and showed the first officer, who was inexperienced on skis, how to jack the landing gear to ensure the spring skis did not adhere to the snow. No tactile test was done to verify that there was no contamination adhering to the wing surfaces. The five passengers were then called from the terminal and boarded the aircraft.

After engine start, the crew were advised that the wind was 160° magnetic at five knots. To reduce taxi time, the captain elected to use the ski strip adjacent to Runway 36 and, given the light wind, decided to take off in a northerly direction. While taxiing, the crew configured the aircraft with a flap setting of 30°.

During the take-off run, the first officer set and monitored the engine power to a take-off setting of 40 pounds per square inch (psi) engine torque. The captain held the control column fully aft until the nose ski lifted off, at which point he lowered the nose slightly to gain airspeed as quickly as possible. The take-off procedure was considered a soft-field take-off by company ski pilots and was routinely performed to reduce stress on the nose gear when operating on unprepared surfaces.

After the nose ski was clear of the snow, the left wing rose and the aircraft veered to the right. Believing that the aircraft was flying and that a power reduction might exacerbate the rolling moment, the captain concluded that a safer course of action was to continue the take-off. He was unaware that the right ski remained in contact with the snow. While the left wing rose, the first officer focused on monitoring and maintaining engine power at 40 psi torque. Other engine instrument readings were not observed and neither pilot detected any indication of an engine malfunction. There were no unusual engine noises.

The captain applied full left rudder, but was unable to stop the rolling moment and attempted to level the wings with full left aileron. He was unable to level the wings, but managed to stop the increase in bank. The aircraft continued in an arc to the right towards a deep gully, still banked to the right with the right ski in contact with the snow. The aircraft became airborne briefly and cleared the gully, but appeared unlikely to clear the trees along the perimeter of the airfield. The captain called for flaps up to reduce drag in an attempt to clear the trees. The aircraft began to sink and the captain called for 30° of flap. The aircraft remained banked to the right; the right wing entered the snow and then struck the airport fence. The aircraft slewed further to the right as it crashed into the trees beyond the fence line. The passengers and crew evacuated the aircraft, sustaining minor injuries.

The flight service station was advised of the crash by another aircraft and a crash response was initiated immediately. Fire suppressant was not required and was not used by responding firefighters.

The tracks made by the aircraft's skis were clearly visible after the accident and indicated that the undersides of the skis were uncontaminated. The tracks along the take-off run were straight and were the depth of the soft snow layer. The tracks showed that the nose ski had lifted first and touched briefly three times before the left main ski lifted at about 900 feet from the start of the ski strip. About 100 feet further, the track of the right main ski began to turn to the right. In the soft snow off the strip, the depth of the right ski track was about five to seven inches until just short of the gully, at which point the aircraft became airborne. The track of the right wing tip began just beyond the gully and arced to the right towards the perimeter fence where the main wreckage trail began.

The ski take-off was normal until the left ski lifted out of the snow. Information contained in the Spring Skiplane Supplement to the Aircraft Fight Manual (AFM) indicated that the nose and left main skis lifted within a range that would have been expected for the take-off technique used and the prevailing conditions.

No pre-impact anomalies were identified with the spring-ski landing gear system. The right ski was found correctly attached to the right landing gear assembly. All support cables and attachment fittings were also properly attached.

An inspection of both engines revealed that the exhaust duct assemblies were twisted, indicative of propeller strikes at high power. Slash marks on trees and damage to both propeller hub assemblies and blades also indicated that the engines were at high power during the impact sequence. Examination of the propellers indicated that the blades were at a low pitch angle at the time of impact. There were no indications of any power loss during the take-off.

The right engine had separated from the nacelle and was found approximately 10 feet behind the right wing. An inspection of the right engine revealed that the inboard and top engine vibration isolator housings, commonly referred to as engine mounts, had completely fractured and that the engine mount bolts were bent. The outboard engine mount was intact and had a torn out piece of nacelle structure attached to it. The fractured mounts were sent to the TSB Laboratory in Ottawa for further analysis, which revealed pre-existing fatigue cracks. However, the bending of the two engine mount bolts indicated that the two fatigued engine mounts were still intact during the take-off run. The analysis indicated that a combination of high propeller rotational forces at impact and the pre-existing fatigue cracks in the right inboard and top engine mounts resulted in overload failure of the two mounts and separation of the right engine.

The Transport Canada (TC) approved operator's maintenance schedule for the company's DHC-6 aircraft required a visual inspection of the engine vibration isolator assemblies after every 200 hours of aircraft flight time to an on-condition specification as listed in the out of phase task requirements. This specification did not require record keeping of the airtime of the individual mounts and company maintenance records did not contain a history of the engine mounts and the total time in service. The manufacturer's aircraft maintenance manual (AMM) requires overhaul or replacement of the engine vibration isolator assemblies every 3000 hours. This entails record keeping of the assembly and inspection of the mounts by florescent dye penetrant.

Damage and imprints to the right side of the fuselage in the area of the flaps indicated that the flaps were extended to 30° at the time of impact. Further inspection of the airframe components including the flap system and the control and trim systems did not reveal any pre-impact anomalies.

Several photographs of the aircraft were taken immediately after the accident. The upper surface of the right wing was visible in the photographs, but the left wing was not. Contamination was visible on the flaps near the right wing root and appeared to extend outwards in the form of a line along the flaperons. Contamination was also visible on the blue painted area surrounding the engine nacelle (see Photo 1.) Patches of oil deposited on the right wing when the right engine tore from its mounts were also visible. These patches of oil were compared to the patches visible in photographs taken the day following the accident when the temperature had increased above zero. Recognizable differences in the size of patches were noted (see Photo 2). This difference was likely caused by the melting of the contamination that had initially trapped the oil and restricted its spread. Wing contamination increases aerodynamic drag and reduces lift.

The following information is provided in Transport Canada's publication TP 14052 - Guidelines for Aircraft Ground-Icing Operations.

> Very slight surface roughness, caused by frozen contaminants, can have extremely significant effects on an aircraft's stalling speed, stalling characteristics, handling qualities and power required due to drag increases.
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> Wing contamination, especially near the leading edge, can cause the wing stalling angle to be reached prior to any indication by the stall warning or stall pusher systems, especially during periods of high angles of attack, such as during the take-off rotation. The pilot will have little or no warning under these conditions. Leading edge roughness, especially during periods of high angles of attack such as during the take-off rotation, has particularly pronounced negative effects on aerofoil performance. Contamination of the leading edge of a wing is therefore of particular concern.
>
> Controllability, especially in the rolling axis, may become extremely difficult or impossible. This lateral control difficulty can occur when the wing is contaminated ahead of the ailerons, thus disrupting the airflow over the aileron and reducing the effectiveness of the aileron. This condition may be exaggerated if the wings are asymmetrically contaminated, that is, if one wing is more contaminated that the other. The consequences of operating an aircraft under these conditions can be grave.

Section 3.6 of the Transwest Air Limited (Transwest) Standard Operating Procedures (SOP) manual states: "When operating in cold weather conditions, all snow, ice and frost shall be removed from the fuselage, wings, ailerons, flaps and tail area including elevators, rudder and stabilons prior to departure." [3]

The following information is provided in Transport Canada publication TP 10643 – When in Doubt... Small and Large Aircraft – Aircraft Critical Surface Contamination Training for Aircrew and Groundcrew: "Unless other procedures have been specifically approved, a tactile external inspection must be conducted on all aeroplanes without leading edge devices."

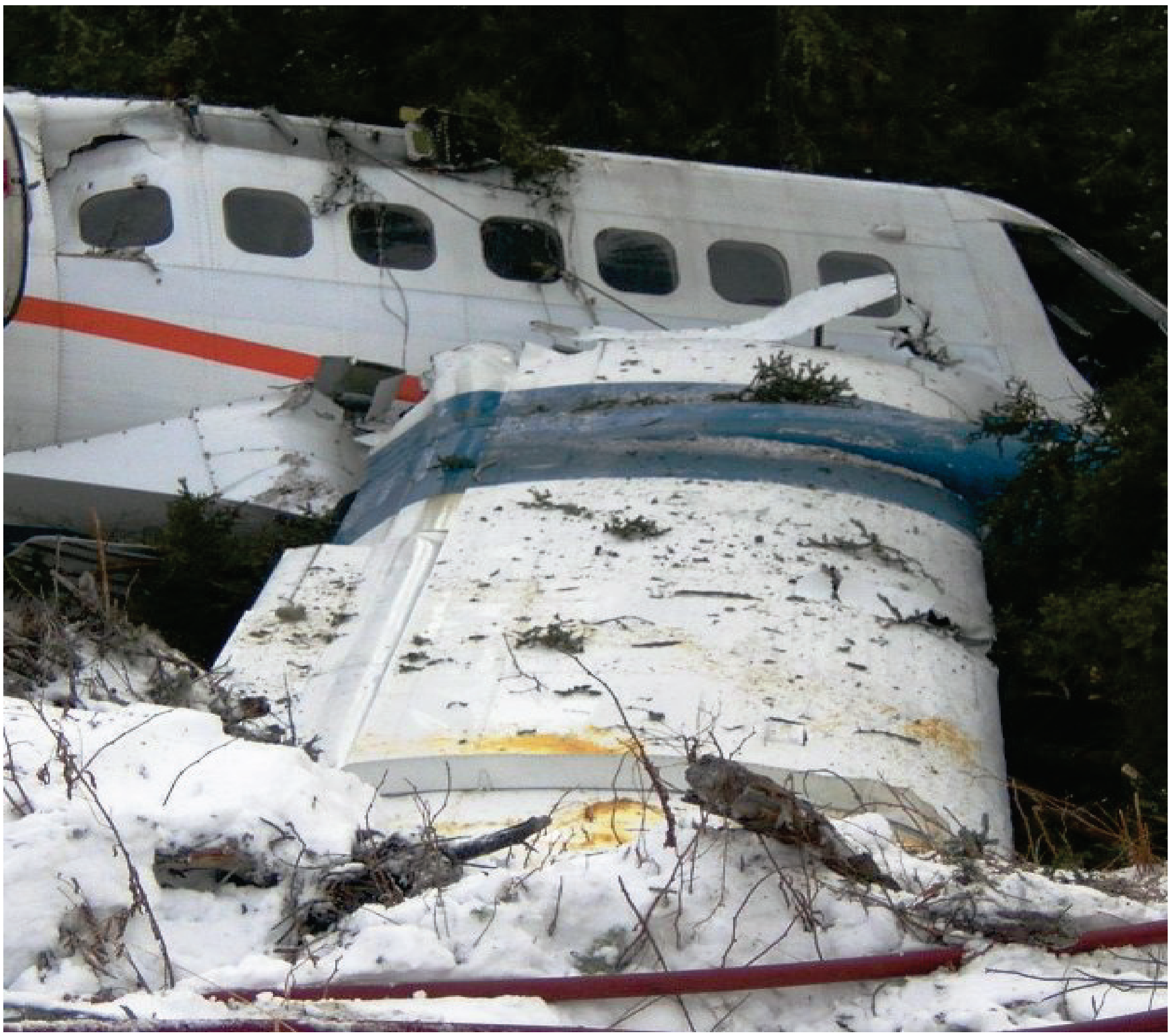

Photo 1. Right wing immediately after the accident

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[3] Subsection 602.11(2) of the *Canadian Aviation Regulations* states that: "No person shall conduct or attempt to conduct a take-off in an aircraft that has frost, ice or snow adhering to any of its critical surfaces."

Photo 2. Right wing two days after the accident.

The Wheel Skiplane and Spring Skiplane Supplement to the AFM for the DHC-6 series 100 indicates that the take-off procedure for the ski-equipped aircraft is identical to that given for the landplane in section 2 of the AFM. In this procedure, the aircraft is flown so as to lift off at a speed determined from the AFM and which meets the requirements of the CARs.

The take-off procedure used by the captain was that specified for short take-off and landing (STOL) performance. Procedures for conducting STOL take-offs are contained in Part 5 of the AFM. A note at the beginning of this part states that the procedures exploit the full STOL capabilities of the aeroplane and do not provide the level of safety required by the CARs for normal category operations, and that they may only be used when specifically authorized by the regulating authority. A STOL take-off reduces an aircraft's margin of safety relative to its stalling speed and minimum control speed (Vmc).

Transport Canada Operations Specification 098, Maximum Performance STOL Take-Off–DHC-6 Twin Otter Aeroplane, was not issued to Transwest. Neither the Transwest Flight Operations Manual nor the SOPs for the DHC-6 provide direction concerning STOL take-offs or landings.

The cockpit voice recorder (CVR) and associated components were removed and analyzed. The CVR contained audio of a previous flight and was not in operation at the time of the occurrence flight. Examination of the CVR system revealed that the impact switch had been tripped. It was not possible to determine accurately when and for how long the CVR had been unserviceable. The aircraft minimum equipment list (MEL) permits dispatch without an operational CVR provided repairs are made within three flight days; however, the CVR control head was not placarded and no entry was made in the aircraft journey log as required by the MEL. The sequence and timing of crew activities during the taxi and attempted take-off could not be rigorously established because of the lack of CVR information.

Transwest holds multiple air operator certificates (AOCs) issued by Transport Canada (TC), including one issued under subpart 705 of the *Canadian Aviation Regulations* (CARs). The CARs require the holder of an AOC operating under subpart 705 to establish, maintain, and adhere to a safety management system (SMS). Furthermore, the SMS shall correspond to the size, nature, and complexity of the operations, as well as the activities, hazards, and risks associated with the operations of the holder of such a certification. Transwest was implementing an SMS throughout its organization, including its Twin Otter operations. SMS is a relatively new concept for the Canadian aviation industry and TC had previously conducted regulatory oversight of Transwest using an inspection/audit approach. A four-phase approach is being used to transition to the SMS.

In January 2007, a Transwest B100 crashed during an overshoot at Sandy Bay, Saskatchewan. The TSB investigation [4] identified that deficiencies in Transwest's supervisory activities permitted the undetected development and persistence of substantial and widespread deviations from SOPs within its King Air operation. At that time (in 2007), the Transwest safety management system was not capable or expected to be capable of detecting, analyzing, and mitigating the risks presented by the hazards underlying the occurrence.

In early 2008, TC conducted an on-site validation that the components and elements required for phase 3 of the implementation of Transwest's SMS were in place and functioning. Completion of phase 3 indicated that Transwest had established a process for the proactive identification of hazards. An acceptance letter was sent to Transwest on 06 March 2008. Completion of phase 4 was expected by the end of 2009.

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[4] TSB Investigation A07C0001

A progress review of Transwest's SMS program was conducted by TC in April 2009 in anticipation of the phase 4 assessment that would be required prior to TC acceptance of the completion of phase 4. The progress review indicated that the reporting system within the company was maturing, but that Transwest was still primarily in the reactive phase of its SMS implementation. Improvement in the corrective action plan (CAP) phase of each internal safety investigation was required. TC did not make any findings or observations about Transwest's supervision of adherence to SOPs.

Analysis

The operator was not authorized for STOL take-off on this aircraft, yet the crew conducted a STOL take-off.

Examination of the snow conditions on the ski strip and the right main ski and attachment fittings indicated that they were not likely factors in the accident sequence. The brief contact marks left by the nose ski after its initial lift-off, closely followed by the lift-off of the left ski, indicated that the aircraft had accelerated to the point that lift-off should have occurred. Because the captain was convinced the aircraft was airborne, it is likely that he interpreted these movements as lift-off and concluded that the aircraft was now airborne. The brief contact marks left by the nose ski also indicate that the captain was initially performing the STOL take-off as outlined in the AFM.

When the aircraft yawed and rolled to the right, the captain elected to continue the take-off, believing it to be a safer course of action than aborting the take-off with the aircraft airborne. The fact that he was able to limit the roll and yaw and to control the nose attitude indicates that the controls were functional. The control response was consistent with the post-impact examination of the control systems, and it is unlikely that a control malfunction was a factor in the accident.

The position of the lift-off of both the nose ski and the left main ski was approximately where lift-off would be expected and indicated that engine power was maintained by the first officer at 40 psi engine torque. Although the right ski was deeper in the softer snow when the aircraft veered, the speed of the aircraft continued to increase and the aircraft become airborne just prior to the gully. This acceleration is indicative of high engine power and is consistent with the post-impact examination of the engines and propellers.

The TSB Laboratory examination and analysis of the fatigue cracks found in the two right engine mounts determined that they likely did not contribute to the occurrence. Consequently, it is unlikely that an engine power loss or malfunction was a factor in the accident.

The maintenance practices for the engine vibration isolator assemblies specified in the AMM are more thorough than the inspection requirements in the approved company maintenance schedule and should have been followed. Because the engine vibration isolator assemblies were inspected visually in accordance with the company's maintenance schedule instead of by fluorescent dye penetrant, fatigue cracking of the engine vibration isolator assemblies was not detected.

When the flaps were raised in an attempt to accelerate and clear the trees, the loss of lift caused the aircraft to descend. Because the aircraft was still in a right bank, the right wing tip entered the snow and hit the fence. The captain had called for the flaps to be re-set to 30º and impact marks on the fuselage were consistent with this selection. The cycling of the flaps produced no aerodynamic movement other than a loss of altitude, which is normal. The behaviour of the aircraft when the flaps were cycled was consistent with the post-impact examination of the flap system and it is unlikely that a flap malfunction was a factor in the accident.

The weather data for La Ronge indicated that there had been two periods of snow after the aircraft had been parked on 29 January 2009 and that, in the afternoon of January 31, temperatures at or above zero had been experienced. Consequently, it was likely that the snow on surfaces of the aircraft melted, and then froze and adhered to the surfaces. Subsequent snowfall covered this contamination. While the snow may have been brushed off by the first officer, removal of all the contamination could not have been confirmed without a tactile test, which was not performed. Consequently, contamination of critical surfaces as revealed by post-accident photography was likely.

No mechanical failure was found that would account for the right yaw and bank after the nose ski and left main ski lifted-off. However, the contamination revealed by photographs on the right wing could have produced degradation in lift and increased drag on the right wing, and kept the wing in a stall condition at the low airspeed of a STOL type take-off. While the condition of the left wing was not documented in the photographs, lift-off of the left wing occurred within the range predicted by the ski supplement to the fight manual. Consequently, the left wing was likely uncontaminated or less contaminated. It is likely, however, that asymmetric contamination of the wings created a lift differential, producing a roll and yaw to the right. The captain's reaction in attempting to lift the wing with aileron would have increased the angle of attack over the right wing and exacerbated the condition. Eventually, the aircraft accelerated to a speed that generated sufficient lift over the right wing, and lift-off of the right ski occurred. The proximity of the trees, however, precluded a safe departure. When the flaps were raised, the lift over the right wing was again reduced and the right wing tip entered the snow.

The two primary anomalies found during the investigation—undetected wing contamination and unauthorized use of STOL take-off techniques—were not identified by the SMS in place at Transwest. Similarly, the two other anomalies—use of a less effective means of inspecting the engine mounts and lack of entry in the aircraft journey log regarding the unserviceability of the CVR—were not detected. A mature, proactive SMS in which all staff work to continuously identify and overcome threats to safety is designed to effectively mitigate such anomalies.

The following TSB Laboratory reports were completed:

LP 018/2009 - Instrument Analysis
LP 019/2009 - Examination of Aileron Cables, Flap Rod, and Assembly
LP 027/2009 - Examination of PT6-20 Engine Mounts

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

Findings as to Causes and Contributing Factors

1. Contamination on the wings of the aircraft was not fully removed before take-off. It is likely that asymmetric contamination of the wings created a lift differential and a loss of lateral control.

2. Although the operator was not authorized for short take-off and landing (STOL) take-off on this aircraft, the crew conducted a STOL take-off, which reduced the aircraft's safety margin relative to its stalling speed and minimum control speed.

3. As a result of the loss of lateral control, the slow STOL take-off speed, and the manipulation of the flaps, the aircraft did not remain airborne and veered right, colliding with obstacles beside the ski strip.

Findings as to Risk

1. The out of phase task requirements regarding the engine vibration isolator assembly, as listed in the operator's maintenance schedule approval, results in a less than thorough inspection requirement, increasing the likelihood of fatigue cracks remaining undetected.

2. The right engine inboard and top engine mounts had pre-existing fatigue cracks, increasing the risk of catastrophic failure.

Other Findings

1. The cockpit voice recorder (CVR) contained audio of a previous flight and was not in operation during the occurrence flight. Minimum equipment list (MEL) procedures for logbook entries and placarding were not followed.

2. The Transwest Air Limited safety management system (SMS) did not identify deviations from standard operating procedures.

Safety Action Taken

The operator has taken the following actions:

All DHC-6 engine mounts have been inspected.

The operator's inspection program has been amended to include the manufacturer's recommendation to overhaul or replace the engine mounts every 3000 hours.

Short take-off and landing (STOL) procedures have been suspended.

This report concludes the Transportation Safety Board's investigation into this occurrence. Consequently, the Board authorized the release of this report on 23 February 2010.

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