

AVIATION OCCURRENCE REPORT

**NORONTAIR
DE HAVILLAND DHC-6-300 TWIN OTTER C-GQKZ
RED LAKE, ONTARIO
19 MARCH 1992**

REPORT NUMBER A92C0048



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 Occurrence Report

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Synopsis

The aircraft became airborne after a take-off ground roll of approximately 300 feet. Initially the aircraft climbed, and then it began to descend. The aircraft then climbed again, more steeply than before, then suddenly descended in a steep nose-down attitude, crashing half-way down the runway. The captain received minor injuries; the first officer was seriously injured. The aircraft sustained substantial damage.

The Board determined that inappropriate short take-off and landing (STOL) take-off procedures were applied, which placed the aircraft in a flight regime outside of the aircraft performance envelope for sustained flight. The aircraft stalled at an altitude from which recovery was not possible.

Contributing to the occurrence was the general acceptance of the use of STOL techniques as an approved procedure.

08 April 1994

Ce rapport est également disponible en français.

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NORONTAIR
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RED LAKE, ONTARIO
19 MARCH 1992

REPORT NUMBER: A92C0048 (Accident)
INFORMATION SOURCE: Field Investigation
LOCAL TIME: 0647 CST
TYPE OF OPERATOR: Air Carrier
TYPE OF OPERATION: Scheduled Domestic
DAMAGE: Substantial
PILOT LICENCE: Airline Transport
-Aeroplane

PILOT-IN-COMMAND

PILOT HOURS:	Last 90 Days	Total
All Types	210	3,000
On Type	210	2,400

CO-PILOT

PILOT HOURS:	Last 90 Days	Total
All Types	225	2 500
On Type	225	1,500

INJURIES:	Crew	Passengers
Fatal	-	-
Serious	1	-
Minor/None	1	-

1.0 Factual Information

1.1 History of the Flight

The occurrence flight was scheduled to proceed from Red Lake to Kenora, and then to Thunder Bay, Ontario. The flight crew arrived at the airport after a seven hour lay-over at Red Lake and prepared for departure. There were no passengers for the leg to Kenora, but there were passengers scheduled to fly out of Kenora to Thunder Bay.

During the taxi to the runway, the pre-take-off checks were completed and the captain conducted the briefing for a standard ten-degree flap take-off. He then decided to practice a short take-off and landing (STOL) type take-off. He informed the first officer, and selected the flaps to 30 degrees. The captain lined up on the button of runway 08. The engines were set to take-off power and after approximately 300 feet of ground roll, the aircraft became airborne. Initially the aircraft climbed, and then it began to descend. It then climbed again, more steeply than before. Suddenly, at approximately 150 feet above

ground level (agl), the aircraft stopped climbing, descended in a steep nose-down attitude, and crashed half-way down the runway.

1.2 Survival Aspects

Both the pilot and the co-pilot were wearing four-point seat-belts, which contributed to the prevention of more serious, or possibly fatal, injury.

1.3 Wreckage and Impact Information

The aircraft crashed 1,642 feet from the threshold of runway 08, just to the right of the runway centre line, at an angle of about 55 degrees nose-down. The main landing gear tires ruptured and the wheel rims showed deformation from the impact forces. Both wings and lift struts broke at the fuselage attachment points. Propeller strike marks from both propellers were clearly visible on the runway, and indicated that both propellers were being powered and were operating at fine pitch. The wings separated from their mounting and support structure, and rotated down and aft. The right wing forward spar attachment failed completely and allowed the wing to flail aft and up, damaging the right horizontal stabilizer. The aircraft slid about another 350 feet as the wing tips and engine propeller spinners scraped along the runway.

An examination of the cockpit revealed that the elevator and rudder trims had been selected to the TAKE-OFF position. The flap selector handle was at the "0" degree position; however, the flap position indicator indicated 32 degrees of flap. The flap actuator was measured; the measurement confirmed that 30 degrees of flap had been extended at the time of impact. The engine fuel selectors and firewall shut-offs were in the OFF position; the throttle and propeller pitch levers were at a very high setting.

1.4 Tests and Research

Tests were conducted on the stall warning system components and on both the pilot's and co-pilot's airspeed indicators. The results

confirmed that all components were operating properly and within accepted tolerances.

The United States National Transportation Safety Board (NTSB) issued a Safety Recommendation #A-80-12, dated 06 February 1980 (see Appendix A), relating to the flight characteristics of the DHC-6 aircraft.

The manufacturer published Revision 42 to the Aircraft Flight Manual, which was approved by Transport Canada on 04 July 1991. Revision 42 updated the normal landing and go-around procedures. The requirement to maintain the appropriate minimum airspeed, and the caution regarding pitch attitude, were reinforced.

Following an investigation into the crash of a passenger-carrying DHC-6-300 Twin Otter that was attempting a STOL take-off in July 1980, Transport Canada's Aviation Safety Bureau recommended that:

All concerned flying personnel and operators should be positively advised to avoid maximum performance procedures for normal category operations.

In addition, on page 5-1 of the Flight Manual P.S.M. 1-63-1, the section 1 caption should be corrected by deleting the word: "NORMAL" and should read: "Maximum Performance STOL Operating Procedures". It is also suggested that the word "Warning" precede note 2 on page 5-1.

A 1985 amendment to PSM 1-63-1 moved the STOL procedures from Section 5 to Section 4 of the manual. Transport Canada's Regulatory Branch subsequently determined that action to address the recommendations was not required.

1.5 Meteorological Information

A special weather observation was taken three minutes after the accident by a contract weather observer located on the airfield. The weather

was reported as thin scattered cloud at 24,000 feet, visibility 15 miles, and a temperature of minus 20.8 degrees. The wind was from 190 degrees at two knots, and there was no precipitation. Weather was not a factor in this occurrence.

1.6 Runway Surface Roughness

A notice to airmen (NOTAM) was issued for runway 08 at Red Lake Airport, advising that there were frost heaves two inches high between 400 and 800 feet from the threshold of runway 08. The crew had printouts of the NOTAMS with them in the cockpit. The pilot reported that a frost heave caused the aircraft to bounce into the air prematurely.

After the occurrence, runway surface roughness tests were conducted on runway 08 at Red lake. Detectable surface irregularities were found at distances of 500 feet and 600 feet from the threshold. The 500-foot irregularity consisted of a rise of 0.75 inches beginning at the 480-foot mark and continuing for a distance of 20 feet. This was followed by a drop off of 1.25 inches over a distance of 30 feet. The 600-foot irregularity involved a gradual rise of 1.6 inches over 70 feet beginning at the 530-foot position, followed by a drop off of 2.2 inches over a distance of 30 feet. The data was plotted on an industry-accepted runway roughness graph; no unacceptable irregularities were found.

1.7 Aircraft Information

The DHC-6 Series 300 Twin Otter (DHC-6-300) is a twin-engine turbo-prop aircraft, with a maximum allowable take-off weight of 12,500 pounds. The aircraft was being used as a commuter airliner and, in its configuration at the time of the occurrence, was capable of carrying up to 17 passengers.

The aircraft was certified, equipped, and maintained in accordance with existing regulations and approved procedures. There was no record of any outstanding aircraft deficiencies. The aircraft was not equipped

with a flight data recorder or a cockpit voice recorder, nor was either required by regulation.

1.8 *Aircraft Flight Manual*

Air Carriers in Canada operate in accordance with an Operating Certificate (OC) which requires that aircraft be operated in accordance with the approved Aircraft Flight Manual (PSM 1-63-1A) or the Aircraft Type Approval No. A-82 (FAA Type Certificate No. A9EA). The DHC-6-300 was given its Aircraft Type Approval based on the requirements of Civil Air Regulations Part 3 (CAR 3). CAR 3 lists the standards for the Aircraft Flight Manual and states that approved information "shall be segregated, identified, and clearly distinguished" from information that is not approved. All pages in the Aircraft Flight Manual are annotated in the top corner with either "DOT Approved" or "MOT Approved." The Aircraft Flight Manual contains only approved information, and all other information is included in the Supplementary Operating Data Manual.

STOL procedures and information are contained in the Supplementary Operating Data Manual (PSM 1-63-1), which is located in the same binder as the Aircraft Flight Manual, and separated from the Aircraft Flight Manual by a tab divider. The Supplementary Operating Data Manual is provided by the manufacturer and is not approved by Transport Canada for general use in the operation of the aircraft. The STOL procedures specifically do not meet the safety criteria required in CAR 3 and therefore require special authorization from Transport Canada prior to use. The fact that the contents of the manual are not approved is signified throughout the document by the lack of a "DOT/MOT Approved" annotation on each page.

According to the approved Aircraft Flight Manual, the only approved take-off procedure for the DHC-6-300 specifies the selection of 10 degrees of flap.

1.9 *Company Manuals*

There are two company manuals that contain company directives regarding DHC-6 operations: the Company Operations Manual, as approved by Transport Canada, outlines the general guidelines and requirements for the company's operation; the DHC-6 Standardization of Procedures (SOP) Manual lists the more detailed procedures relating to operation of the DHC-6. The Supplementary Operating Data Manual is not mentioned in either company manual.

The Company Operations Manual reinforces the requirements of the operating certificate by specifying in the pilot-in-command (PIC) responsibilities section (section 3.2.7.2 para C) that the PIC shall ensure that instructions and limitations of the Aircraft Flight Manual are observed.

When referring to pilot flight training, the Company Operations Manual (section 12.7 para D) encourages en route training in addition to dedicated training times. The determination of what training was to be accomplished en route was left to the discretion of the aircraft captain. No specific training limitations or safe training practices were listed in the company SOP manual; however, it was commonly understood that training exercises that would disturb or affect passenger comfort would not be performed. Training exercises requiring maximum aircraft performance or considerable manoeuvring of the aircraft were restricted to flight legs where only the crew were on board. The use of STOL procedures was discussed with a number of company pilots, including line pilots, supervisory pilots, and company management. Company pilots indicated that they accepted the Max Performance/STOL procedures outlined in the Supplementary Operating Data Manual and used them whenever the appropriate opportunity presented itself.

Neither the Company Operations Manual nor the SOP Manual refers to a maximum performance/STOL take-off or landing procedure. However, the take-off and climb procedures in the DHC-6 SOP manual (section 5 para 5) list duties to be performed during a 20-degree flap take-off.

1.10 STOL Take-Off Procedures

The DHC-6-300 Supplementary Operating Data Manual contains a section stating that for a STOL take-off, the flaps should be selected to the 20-degree position. The control column should be held fully aft until lift-off and then moved forward to control the increasing nose-up attitude. The airspeed should then be allowed to increase to a specified value derived from a performance chart, and then the aircraft can be allowed to continue its climb. Once clear of obstacles, flaps are to be retracted in stages and speed should be increased to the best angle of climb, or best rate of climb speed.

The DHC-6-100 and -200 series Supplementary Operating Data Manuals list a similar take-off procedure except that the initial flap setting specified is 30 degrees. The rationale for reducing to a 20-degree flap setting in the 300 series was an attempt to come closer to conforming to the single-engine climb criteria specified in Special Federal Aviation Regulation No. 23 (SFAR 23). SFAR 23 is a United States Federal Aviation Administration regulation to establish additional airworthiness standards for small airplanes that are to be certified to carry more than ten passengers in commuter airline (FAR Part 135) type operations.

1.11 Personnel Information

The pilots were certified and qualified in accordance with existing regulations. They had adequate crew rest, and duty times were within accepted guidelines. There was no evidence that incapacitation or physiological factors affected either pilot's performance.

The captain had acquired his Airline Transport pilot licence (ATPL) and had been upgraded to captain status within the last year. He had previous experience on DHC-6-100 and -200 series aircraft with another operator prior to his employment with the present company. Since joining the company, he had been well regarded by company training and supervisory personnel. Records indicate that he had satisfactorily completed the required

training in accordance with the Transport Canada (TC) approved training syllabus.

The captain perceived STOL and maximum performance manoeuvres to be covered by the Aircraft Flight Manual and the company SOP Manual, and acceptable for training purposes providing there were no passengers on board. Although the company had not discussed or conducted training involving 30-degree-flap take-offs, he felt it was an acceptable procedure because his previous experience led him to believe that it was commonplace.

1.12 Pilot Actions

The pilot backtracked on runway 08 and lined up for take-off. During the backtrack, the pilot decided to carry out a STOL type take-off and selected 30 degrees of flap. Once the take-off roll started, the pilot left the control column in a near-neutral position. At approximately the point where the aircraft would normally be expected to lift off, the aircraft reportedly hit a frost heave in the runway. The main wheels came off the ground first, and then the aircraft became airborne. The airspeed indicator was observed to be displaying about 40 knots. The aircraft began climbing, and the pilot checked forward on the controls to allow the aircraft to accelerate.

The aircraft began to descend. To avoid hitting the runway, the pilot pulled back on the controls, and the aircraft climbed more steeply. Near the top of the climb, the pilot requested flaps up. The co-pilot selected the flap lever to the "0" degree flap position; however, the aircraft descended into the ground before the flaps retracted.

2.0 *Analysis*

2.1 *The Aircraft*

Examination of the aircraft wreckage and the results of the component tests confirm that there was no evidence of any pre-impact failures or aircraft malfunction that could have contributed to the occurrence.

The NTSB Safety Recommendation #A-80-12 describes the unique pitch attitudes required when operating DHC-6 aircraft with full flap selected. The occurrence aircraft had 30 degrees of flap selected; however, by approximation, aircraft handling was not considered to be radically different from that experienced at full (37.5 degrees) flap. The aircraft's steep climb at low speed followed by a steep nose-down attitude and descent into the ground is indicative of an aerodynamic stall. The NTSB research corroborates this conclusion.

2.2 *Runway Surface Roughness*

The aircraft ground roll was reported to be approximately 300 feet. The first surface irregularity started at 480 feet. Additionally, the first frost heave consisted of a small rise over a relatively long distance; its dimensions were well within acceptable limits. Therefore, it is not likely that the minor frost heaves on runway 08 significantly affected the aircraft during the take-off sequence.

2.3 *Flight Manual*

The contents of an approved Aircraft Flight Manual are dictated by the certification standards, in this case, CAR 3. No standards are specified for additional information provided by the manufacturer, although a wealth of information, including critical flight safety advisories, is available from the manufacturer and is placed in the Supplementary Operating Data Manual. In the absence of any standard for non-approved information, the accepted standard appears to be the absence of any page marking, which

thereby denotes the information's non-approved nature.

There are many directives regarding operation in accordance with the approved Aircraft Flight Manual, but there is no direction as to whether supplementary data or non-approved portions may be used by pilots and operators. The situation is further complicated by the fact that the binder commonly considered to be the Aircraft Flight Manual contains both approved and non-approved information and procedures.

2.4 *Company Procedures*

The company SOP manual included procedures for 20-degree (STOL) take-offs that conform with the STOL procedures specified by the manufacturer. The procedures were based closely on the information in the Supplementary Operating Data Manual.

The company policy of encouraging en route training in addition to dedicated training requirements is laudable. However, the absence of training restrictions, other than passenger comfort considerations, may have allowed an attitude to develop where captains welcomed the opportunity to practice maximum performance manoeuvres. Many pilots may not be familiar with the safety standards specified in aircraft certification criteria such as CAR 3. A number of company pilots accepted the Max Performance/STOL procedures outlined in the Supplementary Operating Data Manual and used them whenever the appropriate opportunity presented itself.

2.5 *The Pilot*

The captain's previous flying experience and training on DHC-6-200 series aircraft led him to believe that the selection of 30 degrees of flap was suitable for a STOL take-off.

The manipulation of the flight controls and handling of the aircraft did not conform to the STOL procedure specified for the 300 series aircraft. There is little room for error

during STOL procedures, and once the aircraft was outside of its flight envelope, there was no effective means available to the pilot to regain control of the aircraft.

3.0 *Conclusions*

3.1 *Findings*

1. Both pilots were wearing seat-belts and shoulder harnesses which contributed to the prevention of more serious injuries to the crew.
2. The pilots were certified and qualified in accordance with existing regulations.
3. The crew had adequate rest, and duty times were within accepted guidelines.
4. There was no evidence of any pre-impact failures or aircraft malfunction that could have contributed to the occurrence.
5. It is not likely that the minor frost heaves on runway 08 significantly affected the aircraft during the take-off sequence.
6. The company SOP manual included procedures for 20-degree (STOL) take-offs that conform with the STOL procedures specified by the manufacturer in the non-approved Supplementary Operating Data Manual.
7. Thirty degrees of flap was used for this take-off. The only approved take-off procedure for the DHC-6-300 specifies the selection of 10 degrees of flap.

8. The STOL take-off technique applied placed the aircraft in a flight regime outside of the aircraft performance envelope for sustained flight.

3.2 *Causes*

Inappropriate short take-off and landing (STOL) take-off procedures were applied, which placed the aircraft in a flight regime outside of the aircraft performance envelope for sustained flight. The aircraft stalled at an altitude from which recovery was not possible.

Contributing to the occurrence was the general acceptance of the use of STOL techniques as an approved procedure.

4.0 *Safety Action*

4.1 *Action Taken*

4.1.1 *Air Carrier's Actions*

Following this occurrence, the air carrier conducted an internal review of its policies, procedures, and training practices to assure their correctness. Also, the company pilots were directed not to use STOL procedures on the Twin Otter aircraft.

4.1.2 *Transport Canada's Actions*

Based on the information gathered during the initial stages of the investigation, Transport Canada advised its regional offices that all Twin Otter operators should be made aware that STOL operations outlined in the Supplemental Operating Procedures are not authorized in commercial operations.

4.2 *Action Required*

4.2.1 *Knowledge of Aircraft Flight Manuals*

A single binder was used by the air carrier to hold the approved Aircraft Flight Manual (PSM 1-63-1A) and the non-approved Supplementary Operating Data Manual (PSM 1-63-1). This is an accepted practice in the aviation industry, and the combination binder is commonly referred to as the "Aircraft Flight Manual." Generally, a tab divider separates the two portions of the binder; in practice, little distinction is made between the "approved" and "non-approved" contents. It is not uncommon to find flight manual binders with the two categories of information inter-mixed, most likely as a result of years of local reproduction of the original manuals.

The mandatory or "approved" portion of the flight manual binder is generally comprised of the aircraft certification information relating to airspeeds, power plant and weight limitations, normal and emergency operating procedures, aircraft performance data, and loading parameters. The flight

manual binder may contain supplemental operating procedures. Since this additional material has not necessarily been reviewed by the certification authority, it is referred to as "non-approved" information. Typically, this section includes acceleration-stop distances, specific range and cruise power charts, some climb and descent performance, system descriptions, maintenance procedures, and other handling characteristics. It often holds manufacturer-issued safety bulletins or communiqués covering topics from product enhancements to revised recommended operating procedures. However, at times, this "non-approved" information from the manufacturer goes beyond the "nice-to-know" category, by providing information essential for flight safety.

"Non-approved" material can generally be divided into two types: information which was not required for the certification of the aircraft, and information that did not meet the safety/performance level required during certification of the aircraft. The STOL procedures for the Twin Otter aircraft belong to the latter category.

The operator involved in this occurrence had separated the two categories of information in the flight manual binder. The company SOPs included duties for a 20-degree STOL take-off based on the "non-approved" procedure. Apparently, the company pilots considered this procedure as a "normal" training sequence, most likely unaware that the STOL procedure did not meet the safety criteria for commercial flight operations.

While there are guidelines on the use of "approved" information, there is no direction as to how the "non-approved" portion of the flight manual binder may be used by pilots and operators. Explanation of the differences between "approved" and "non-approved" information in flight manual binders is not required in initial or recurrent pilot training, nor is it found in commonly used flight publications. Hence, many in the aviation community are unaware of the differences. This lack of understanding regarding the proper use of the "non-approved" information

contained in aircraft flight manual binders could result in pilots employing unsafe procedures. Therefore, the Board recommends that:

The Department of Transport promulgate guidelines regarding the use of "non-approved" material contained in aircraft flight manuals, including related operational information issued by aircraft manufacturers; and

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The Department of Transport incorporate the subject of "approved" and "non-approved" aircraft flight information in the syllabus for initial pilot training.

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4.2.2 DHC-6 (*Twin Otter*) STOL Performance

The Twin Otter aircraft has an international reputation as a STOL aircraft, and it is often employed in operations demanding short field operations. However, to indicate that the maximum performance STOL configuration of the Twin Otter does not meet certification standards, the manufacturer has provided a "NOTE" in the "Normal Operating Procedures" section of the Supplementary Operating Data Manual.

International aircraft publication standards of the General Aviation Manufacturers' Association and the Air Transport Association promote the use of a system of NOTES, CAUTIONS, and WARNINGS in flight manuals. A "NOTE" is meant to expand further on a topic; a "CAUTION" deals with matters that, if not strictly observed, could result in damage or destruction of equipment; and a "WARNING" directs attention to potentially critical information that, if disregarded, could lead to personal injury or loss of life. Although air crew may not know the exact definitions of NOTES, CAUTIONS, and WARNINGS, they are generally familiar with their relative importance through frequent exposure to them; that is, NOTES receive less attention than CAUTIONS and WARNINGS.

The use of the word "Normal" in the Twin Otter Supplementary Operating Data Manual to describe STOL procedures that do not provide the level of safety required by regulations for Normal Category Operations is misleading. Further, the message contained in the associated NOTE is more in line with what air crew would expect to be labelled as a WARNING.

As evidenced by this occurrence, the limitations of operating the Twin Otter in the maximum performance STOL configuration were not fully recognized by at least one Canadian operator. Consequently, Transport Canada issued a memorandum to its Regional Directors General on "the widespread use of unauthorized STOL procedures" for the DHC-6, alerting TC officials "to the hazards inherent in these procedures." The memorandum indicated "that operators should be made aware that the use of these procedures are not permitted" and "inspectors should ensure that these unapproved STOL operations are not being utilized by operators." Except for the internal Transport Canada memorandum, the Board is not aware of any formal communication or direction being given to Canadian operators regarding "non-approved" STOL procedures for the DHC-6. In March 1994, four randomly chosen DHC-6 operators in different regions across Canada indicated that Transport Canada had not contacted them regarding STOL procedures, and that STOL take-offs were being employed. Furthermore, given that the DHC-6 is widely used throughout the world, there does not appear to have been any related correspondence to international agencies responsible for foreign DHC-6 operators.

Since the DHC-6 Twin Otter is marketed as a STOL aircraft, since the information provided by the manufacturer regarding limitations on the "non-approved" procedures for maximum performance STOL take-offs is misleading, and since Transport Canada has advised its Regional Directors General that "the use of these procedures are not permitted," there is room for considerable misunderstanding in the global aviation community regarding the safe operation of this

aircraft in the STOL configuration. Therefore, the Board recommends that:

The Department of Transport define, through a program of flight testing, the aircraft configuration and operating conditions under which "maximum performance" STOL take-offs are authorized; and

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The Department of Transport take the necessary measures to advise all DHC-6 operators on a global basis of the operating limitations for these "authorized maximum performance" STOL procedures; and

A94-16

The Bombardier Corporation amend the Twin Otter (DHC-6) Aircraft Flight Manual (PSM 1-63-1A) and Supplementary Operating Data Manual (PSM 1-63-1) to include appropriate warnings regarding any safety limitations associated with the operation of the aircraft in the "maximum performance" STOL configuration.

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This report concludes the Transportation Safety Board's investigation into this occurrence. Consequently, the Board, consisting of Chairperson, John W. Stants, and members Gerald E. Bennett, Zita Brunet, the Hon. Wilfred R. DuPont and Hugh MacNeil, has authorized the release of this report.

Appendix A - NTSB Safety Recommendation

