AVIATION INVESTIGATION REPORT
A98A0191

COLLISION WITH TREES

KNIGHTHAWK AIR EXPRESS LIMITED
DASSAULT-BREGUET FALCON 20D C-GTAK
ST. JOHN'S, NEWFOUNDLAND
30 DECEMBER 1998

Aviation Investigation Report

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Synopsis

Knighthawk flight 8073, a Falcon 20D aircraft, serial number 197, was a cargo flight from Gander, Newfoundland, with two pilots on board. The aircraft was on an instrument approach to runway 16 at St. John's, Newfoundland. During the approach, severe turbulence and wind shear were encountered. This resulted in a sudden loss of altitude and impact with the tops of trees. The crew executed a wind shear recovery, declared an emergency, and then carried out a second uneventful approach to the same runway. The aircraft sustained substantial damage to the left wing; there were no injuries to the crew.

Ce rapport est également disponible en français.

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1.0 Factual Information

1.1 History of the Flight

Knighthawk flight 8073 was being operated by Knighthawk Air Express Limited in a cargo configuration. The aircraft departed Gander for St. John's at 1445 Newfoundland standard time (NST).[1] En route, the crew was informed that the glide slope for the instrument landing system (ILS) to runway 16 and the wind speed indicator (anemometer) at the airport were unserviceable. The crew was given an estimated wind of 150 degrees magnetic at 10 knots, gusting to 25 knots. Although the ceiling was reported below landing minima for the localizer approach to runway 16, the crew decided to attempt the approach after receiving a pilot report (PIREP) from an aircraft which had just landed on runway 16. The PIREP did not contain any comment on turbulence.

At approximately 20 nautical miles (nm) from the airport, the aircraft was cleared for the localizer approach for runway 16. During the initial part of the descent into St. John's, only light turbulence was encountered. At about 3000 feet above sea level (asl), the captain, who was the pilot flying, reduced the descent rate and speed. At about this time, a marked increase in turbulence occurred followed shortly thereafter by a rapid increase in airspeed and drift. The crew members were not overly concerned by the turbulence as they had flown into St. John's several times in the previous week and had encountered similar conditions. The crew configured the aircraft for landing and had begun a correction toward the localizer when the turbulence became severe. Shortly thereafter, there was an uncontrollable and rapid loss of altitude. The first officer believed that, during the rapid descent, he saw the ocean followed quickly by the presence of terrain. He also believed he shouted "terrain" to the captain. The captain initiated a wind shear recovery by applying maximum power and increasing the pitch attitude until the stall warning was heard. At about this time, the aircraft descended into the trees at 1515. After clipping several trees, the aircraft began to climb, the crew discontinued the approach, and an emergency was declared. During vectors for a second approach, the glide slope became serviceable and an uneventful ILS approach and landing were carried out.

1.2 Injuries to Persons

	Crew	Passengers	Others	Total
Fatal	-	-	-	-
Serious	-	-	-	-
Minor/None	2	-	-	2
Total	2	-	-	2

[1] All times are NST (Coordinated Universal Time (UTC) minus 3.5 hours) unless otherwise stated.

1.3 Damage to Aircraft

The left wing sustained the following damage: approximately three feet of the outboard droop leading edge was torn loose and curled under the wing; the outboard wing extension lower skin was twisted; and the aileron and outboard flap panel exhibited minor damage. The left wing inboard droop and fixed leading edges exhibited several substantial impact marks.

1.4 Other Damage

Ground damage was restricted to several black spruce trees in an unpopulated area. The six- to seven-foot tall trees had been broken off three to four feet above the ground.

1.5 Personnel Information

	Captain	First Officer
Age	27	35
Pilot Licence	ATPL	ATPL
Medical Expiry Date	01 October 1999	01 September 1999
Total Flying Hours	4591	4905
Hours on Type	750	600
Hours Last 90 Days	195	140
Hours on Type Last 90 Days	195	140
Hours on Duty Prior to Occurrence	8	6
Hours Off Duty Prior to Work Period	12	12

1.6 Aircraft Information

Manufacturer	Dassault-Breguet
Type and Model	Falcon 20D
Year of Manufacture	1969
Serial Number	197
Certificate of Airworthiness (Flight Permit)	3 January 1996
Total Airframe Time	20 252
Engine Type (number of)	General Electric CF-700-2D (2)
Maximum Allowable Take-off Weight	28 660 lb
Recommended Fuel Type(s)	Jet A, Jet A-1, Jet B
Fuel Type Used	Jet A-1

1.6.1 Weight and Balance

The weight and centre of gravity were within the prescribed limits.

1.7 Meteorological Information

1.7.1 Area Forecast (FA)

The FA received by the crew from their dispatch prior to departure was FACN33 CYQX. However, this forecast was for the Flemish Region which did not include the area around St. John's. The appropriate FA for the St. John's region was FACN31 CYQX, issued at 1130 and 1730 UTC. FACN31 forecast moderate to severe mechanical turbulence below 3000 feet due to strong gusting surface wind.

1.7.2 Aerodrome Forecast (TAF) and Aviation Routine Weather Reports (METAR)

Before departure, the crew received a TAF for St. John's Airport, issued at 1631 UTC, which indicated that the weather for the period from 1700 to 2000 UTC would be as follows:

> Surface winds 110 degrees true at 25 knots gusting to 35 knots, visibility 0.5 statute mile (sm) in light freezing rain and fog, vertical visibility 200 feet, temporarily 3 sm in light freezing rain, light snow pellets and light freezing drizzle, 1000 feet overcast.

Also received was the following METAR for St. John's Airport valid at 1800 UTC:

> Surface winds 140 degrees true at 15 knots gusting to 25 knots, visibility 1 sm in light freezing rain and mist, runway 16 visual range 5000 feet, vertical visibility 100 feet, temperature zero degrees Celsius, dewpoint minus one degree Celsius, altimeter setting 29.51, remarks: fog 8 octas, present surface wind speed is estimated, pressure falling rapidly.

NOTE: The surface wind speed was estimated because the anemometer was not functioning, probably due to the freezing precipitation. A frozen anemometer was a finding in a previous report (A97H0003) and the subject of a TSB *Aviation Safety Advisory* circular (A970044). Over the winter of 1999/2000, Environment Canada had carried out performance evaluations of heated anemometers; however, further tests are needed to complete the evaluation.

1.7.3 Winds Aloft

The wind at 3000 feet in the St. John's area was forecast to be 180 degrees true, 39 knots. The forecast surface wind at St. John's for the landing period was 110 degrees true at 25 knots, a directional difference of 70 degrees.

1.7.4 Mechanical Turbulence

Mechanical turbulence is caused by friction between the ground and moving air (wind). In areas of relatively flat, even ground, this effect is minimal; however, if the surface of the ground is uneven, the probability and severity of turbulence increase with the asperity of the terrain and strength of the wind. Both the terrain and the wind conditions around St. John's Airport were conducive to severe mechanical turbulence.

Severe turbulence, and the wind shear and downdrafts that can be associated with it, are often contained in a relatively small area. Aircraft operating adjacent to an area of reported turbulence may experience little or no turbulence at all.

1.7.5 Low Level Wind Shear

Wind shear is defined as a change in wind speed and/or direction in a short distance resulting in a tearing or shearing effect; it can exist in a horizontal or vertical direction, and occasionally in both. The flight crew reported a significant and rapid change in drift and airspeed just before the sudden loss of altitude which were conditions typical of a wind shear encounter.

1.7.6 Downdrafts

When strong winds blow over precipitous terrain, severe downdrafts can occur on the leeward side of the terrain. Aircraft entering this area of descending terrain may encounter downdrafts of such severity that the climb performance of the aircraft is insufficient to overcome the descent. The type of terrain along the approach path to several runways at St. John's Airport, including runway 16, is conducive to these downdrafts; at least

two previous accidents[2] at St. John's have been attributed to this phenomenon.

1.8 Aids to Navigation

As the glide slope was unserviceable, the crew attempted a straight-in non-precision localizer approach for runway 16. The crew was using an instrument approach procedure chart effective 26 February 1998, from the Air Canada route manual.

The *Canada Air Pilot* (CAP) approach plates for St. John's Airport formerly contained a cautionary note which stated "Dangerous downdrafts all runways especially Runway 16 with south winds". This cautionary note was amended on 25 June 1992 and now states "Moderate to severe turbulence may be anticipated".

The cautionary note in the Air Canada approach plate used by the crew stated:

> WARNING
> MODERATE TO SEVERE TURBULENCE MAY BE ANTICIPATED.

In the aerodrome/facility directory of the *Canada Flight Supplement* (CFS), several airport listings contain information on the probability of moderate to severe turbulence in high-wind conditions. No information in the CFS listing for St. John's Airport informs pilots of the existence of these conditions.

1.9 Communications

Communication between the aircraft and air traffic control was maintained throughout the flight.

1.10 Aerodrome Information

The field elevation at St. John's Airport is 461 feet asl. Steep cliffs and headlands rise sharply out of the ocean to the east, southeast, and northwest of the airport. The localizer approach to runway 16 extends to the northwest of the airport.

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2 Occurrence numbers A85A4048 and A91A0044

During the intermediate portion of the localizer approach for runway 16, aircraft may descend from 2000 feet asl at the initial approach fix (IAF), down to 1600 feet asl and must maintain a minimum of 1600 feet asl until over the final approach fix (FAF). While transiting from the IAF to the FAF, an aircraft crosses over cliffs which rise approximately 900 feet from the ocean. The minimum obstacle clearance altitude for the intermediate approach segment is determined by these cliffs. In this case, obstacle clearance approach design criteria found in Transport Canada's (TC) TP 308, *Criteria for the Development of Instrument Procedures*, only require the altitude on the intermediate approach to be 1500 feet asl; however, other design criteria raised the altitude to 1600 feet asl.

Section 323 of TP 308, "Minima Adjustments", states the following:

> Raising the minimum descent altitude (MDA) or decision height (DH) above that required for obstacle clearance may be necessary under the following conditions:
>
> a. Precipitous Terrain. When procedures are designed for use in areas characterized by precipitous terrain, in or outside of designed mountainous areas, consideration must be given to induced altimeter errors and pilot control problems which result when winds of 20 knots or more move over such terrain. Where these conditions are known to exist, required obstacle clearance in the final approach segment should be increased. Procedure designers and approving authorities should be aware of such hazards involved and make appropriate addition, based on their experience and good judgement, to limit the time in which an aircraft is exposed to lee-side turbulence and other weather phenomena associated with precipitous terrain. This may be done by increasing the minimum descent altitude over the intermediate and final approach fixes so as to preclude prolonged flight at low altitudes. User comments should be solicited to obtain the best available local information.

Discussions with approach designers indicated that the intermediate approach altitude of 1600 feet could be increased to as much as 1900 feet and still meet the maximum gradient for the approach.

1.11 Flight Recorders

The aircraft was not equipped with a flight data recorder or a cockpit voice recorder, nor was either required by regulation.

1.12 Wreckage and Impact Information

The aircraft struck the tops of trees on a 920-foot hill, slightly right of the approach path, 2 nm from the final approach fix, and 5.5 nm from the threshold of runway 16.

1.13 Medical Information

There was no indication that incapacitation or physiological factors affected the crew's performance.

1.14 Fire

There was no fire before or after the occurrence.

1.15 Survival Aspects

The timely application of wind shear recovery techniques likely prevented more serious and potentially fatal consequences.

1.16 Tests and Research

No tests or research were conducted.

1.17 Organizational and Management Information

The operator holds a valid air operator certificate issued under Part VII, "Commercial Air Services", of the Canadian Aviation Regulations (CAR). The main operating base is at Ottawa Airport and sub-bases are maintained at Toronto/Lester B. Pearson and Calgary airports. The Falcon 20 is operated under CAR 704, Subpart 4, "Commuter Operations".

1.18 Additional Information

1.18.1 Altimeter Error

The flight crew reported that the lowest indicated altimeter reading observed during the occurrence was 1300 feet asl, and the lowest observed altitude on radar was 1200 feet asl. As the aircraft struck the trees at 920 feet asl, this indicates a likely altimeter error of at least 280 feet. Altimeter errors as much as 2500 feet have been recorded in downdrafts. The aircraft altimeters were tested by the operator after the occurrence and found to be within prescribed limits.

1.18.2 Crew Training

The crew had undergone wind shear recovery training in an approved Falcon 20 flight simulator.

2.0 Analysis

2.1 Introduction

The aircraft was determined to have been serviceable for the flight and there was no indication of impairment in crew performance. Consequently, the analysis will deal with the following factors: weather information available to the crew, crew decision making, crew information and preparedness, and aerodrome information at St. John's.

2.2 Weather Information

Approximately seven minutes before the accident, the flight crew received the latest surface wind conditions at the airport which indicated the wind speed to be 15 to 25 knots estimated. The wind speed was estimated due to the fact that the wind speed indicator at the airport was unserviceable. According to the aerodrome forecast, the wind speed was expected to be 25 knots gusting to 35 knots. The area forecast indicated wind speeds of as much as 25 to 35 knots gusting to 50 knots. Based on the forecasts and the conditions encountered on approach, it is probable that the wind encountered on approach was much stronger than that which was reported to the flight crew. The forecast and actual weather conditions at St. John's were conducive to turbulence, wind shear, and downdrafts.

2.3 Crew Decision Making

The flight crew members decided to continue to their destination after they were advised that the weather was going to be below the landing minima for the only available approach. This decision was based on a PIREP relayed from an aircraft which landed safely approximately 18 minutes before the accident; the PIREP had given no indication of turbulence.

On the approach, the crew was not concerned with the presence of the moderate turbulence during the initial stages because they had flown into St. John's several times in the previous week and encountered similar conditions. However, they were not prepared for the presence of the wind shear and the severe downdraft which followed.

2.4 Crew Information and Preparedness

The predominance of information regarding severe downdrafts is generally associated with thunderstorms or mountainous regions. Flight crews are provided with information, strategies, and/or training for managing their flights safely when such conditions may be encountered. However, available awareness training or information is limited for the circumstances which this crew faced in St. John's; no thunderstorms were present, and the terrain is not generally considered to be mountainous. The only weather advisory existed on the approach plates, and it provides a warning of turbulence in strong wind conditions.

The fundamental strategy for operating safely in conditions where severe weather exists is avoidance. This strategy can only be implemented if the crew has the correct information for the area in which the flight will be conducted. The FA included in the weather package that the crew had received prior to departure was not the correct forecast for the St. John's area and only forecasted light to nil turbulence.

The crew response and recovery action when the downdraft occurred were considered appropriate.

2.5 Aerodrome Information

The only advisory of the presence of potentially adverse conditions on approach to St. John's Airport is provided on the approach plates. A cautionary note warns pilots that they may anticipate moderate to severe turbulence; however, in previous issues of the charts, pilots were advised that dangerous downdrafts could exist on the approaches. The more appropriate warning is that which advises of the potential for dangerous downdrafts.

Pilots who approach the St. Johns's Airport under visual flight rules (VFR) may not have reference to the instrument approach procedure charts. As there is no mention of turbulence in the CFS, VFR pilots may be unaware of turbulence hazards around the airport.

Section 323 of TP 308, *Criteria for the Development of Instrument Procedures*, would allow for an increase in the intermediate approach altitude and FAF crossing altitude for runway 16. This increase in the minimum altitude would help to position aircraft above downdrafts and would help to limit the amount of time that aircraft would be exposed to the hazards associated with lee-side phenomena associated with precipitous terrain. It would also provide the aircraft with more terrain clearance in the event of an inadvertent encounter with a downdraft; the altitude could be increased from the present 1600 feet to as much as 1900 feet. Had this buffer been applied, it is possible that the aircraft would not have struck the trees.

3.0 Conclusions

3.1 Findings as to Causes and Contributing Factors

1. The weather conditions on the approach at St. John's Airport were conducive to severe turbulence, wind shear, and downdrafts.

2. The aircraft encountered severe turbulence and downdrafts which caused a sudden loss of altitude and subsequent impact with the trees.

3. The pilot applied the correct wind shear recovery techniques.

3.2 Other Findings

1. The flight crew members were certified, qualified, and trained to operate the aircraft in accordance with existing regulations.

2. The weight and centre of gravity of the aircraft were within the prescribed limits.

3. The cautionary note warning of downdrafts in the instrument approach procedures charts for St. John's airport was removed.

4. The listing for the St. John's Airport in the CFS did not contain information which warns of the existence of severe turbulence, wind shear, and downdrafts.

5. The obstacle clearance altitude on the intermediate approach does not take into account the precipitous terrain criteria contained in TP 308, *Criteria for the Development of Instrument Procedures*.

4.0 Safety Action

4.1 Action Taken

4.1.1 Safety Memo

Within days after the accident, the operator issued a safety memo to all company personnel informing them of the circumstances surrounding the accident and the potential wind shear hazard at St. John's.

4.1.2 Aviation Safety Advisories

Two aviation safety advisories have been sent to TC. One advisory has identified the absence of consideration for the wind conditions and precipitous terrain at St. John's in obstacle clearance height determination. The other advisory identified the inadequacy of pilot information regarding the potential hazardous weather/wind conditions. Both advisories suggested that these circumstances could be present at other airports in Canada.

In its response to the advisories, TC indicated that both TC and NAV CANADA concur with the subject of the advisories. Furthermore, NAV CANADA has indicated to TC that on the "Publication of Turbulence Advisories", they will implement procedures to ensure that information is available to pilots regarding potential hazardous weather/wind conditions; on the "Obstacle Clearance Criteria - Precipitous Terrain" advisory, NAV CANADA has indicated to TC that they will examine the modalities of its application at St. John's.

4.1.3 Cautionary Information

After being informed of the lack of information on turbulence, windshear, and downdrafts in the CFS, NAV CANADA is initiating action to include this information in the CFS.

TC is also advising the regional managers of Aerodrome Safety to be vigilant in ensuring that relevant cautionary notes on approach plates are also provided in the appropriate sections of the CFS.

This report concludes the Transportation Safety Board's investigation into this occurrence. Consequently, the Board authorized the release of this report on 07 June 2000.

Appendix A - Glossary

asl	above sea level
ATPL	airline transport pilot licence
CAP	*Canada Air Pilot*
CAR	Canadian Aviation Regulations
CFS	*Canada Flight Supplement*
DH	decision height
FA	area forecast
FAF	final approach fix
IAF	initial approach fix
ILS	instrument landing system
lb	pound(s)
MDA	minimum descent altitude
METAR	aviation routine weather report
nm	nautical mile(s)
NST	Newfoundland standard time
PIREP	pilot report of weather conditions in flight
sm	statute mile(s)
TAF	aerodrome forecast
TC	Transport Canada
TSB	Transportation Safety Board of Canada
UTC	Coordinated Universal Time
VFR	visual flight rules