AVIATION INVESTIGATION REPORT
A99A0036

CONTROLLED FLIGHT INTO TERRAIN

PROVINCIAL AIRLINES LIMITED
DE HAVILLAND DHC-6-300 TWIN OTTER C-FWLQ
DAVIS INLET, NEWFOUNDLAND 2 nm NNE
19 MARCH 1999

Transportation Safety Board
of Canada

Bureau de la scurit des transports

du Canada

Aviation Investigation Report

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Synopsis

The de Havilland DHC-6-300 Twin Otter, serial number 724, was on a defence visual flight rules flight from Goose Bay to Davis Inlet, Newfoundland, with a crew of two on board. The flight encountered instrument meteorological conditions en route and continued to Davis Inlet in these conditions under the defence visual flight rules flight plan. The crew flew a non-precision instrument approach to the airport and, at minimums, executed a missed approach because the required visual references were not established. A second approach was attempted; on the inbound track, the aircraft struck the frozen surface of the Labrador Sea two nautical miles north-northeast of the airport. The first officer was fatally injured, and the captain sustained serious injuries. The aircraft was destroyed.

Ce rapport est également disponible en français.

1.0 Factual Information

1.1 History of the Flight

The flight was a pilot self-dispatched, non-scheduled cargo flight from Goose Bay to Davis Inlet, Newfoundland, and was operating as Speed Air 960 under a defence visual flight rules flight plan. Before the flight, the captain received weather information from the St. John's, Newfoundland, flight service station (FSS)[1] via telephone and fax. The aircraft departed for Davis Inlet at 0815 Atlantic standard time (AST).[2]

The captain was the pilot flying (PF). During the first approach, the first officer (FO) had occasional visual glimpses of the snow on the surface. The captain descended the aircraft to the minimum descent altitude (MDA) of 1340 feet above sea level (asl). When the crew did not acquire the required visual references at the missed approach point, they executed a missed approach.

On the second approach, the captain flew outbound from the beacon at 3000 feet asl until turning on the inbound track. It was decided that if visual contact of the surface was made at any time during the approach procedure, they would continue below the MDA in anticipation of the required visual references. The captain initiated a constant descent at approximately 1500 feet per minute with 10 degrees flap selected. The FO occasionally caught glimpses of the surface. At MDA, in whiteout conditions,[3] the captain continued the descent. In the final stages of the descent, the FO acquired visual ground contact; 16 seconds before impact, the captain also acquired visual ground contact. At 8 seconds before impact, the crew selected maximum propeller revolutions per minute. The aircraft struck the ice in controlled flight two nautical miles (nm) from the airport (see Appendix B). During both approaches, the aircraft encountered airframe icing. The crew selected wing de-ice, which functioned normally by removing the ice.

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1 See Appendix E—Glossary for abbreviations and acronyms.

2 All times are AST (Coordinated Universal Time [UTC] minus four hours) unless otherwise stated.

3 Whiteout conditions occur over unbroken snow cover and beneath a uniformly overcast sky. The terrain is virtually devoid of visual cues, and the eye no longer discerns the surface or terrain features.

1.2 Injuries to Persons

	Crew	Passengers	Others	Total
Fatal	1	-	-	1
Serious	1	-	-	1
Minor/None	-	-	-	-
Total	2	-	-	2

1.3 Damage to Aircraft

The aircraft was destroyed.

1.4 Other Damage

There was no other damage.

1.5 Personnel Information

	Captain	First Officer
Age	51	22
Pilot Licence	ATPL	CPL
Medical Expiry Date	01 September 1999	01 September 1999
Total Flying Hours	16 000	500
Hours on Type	2500	70
Hours Last 90 Days	105	70
Hours on Type Last 90 Days	105	70
Hours on Duty Prior to Occurrence	2.6	2.6
Hours Off Duty Prior to Work Period	48	72

1.5.1 General

The two pilots were trained in accordance with the operator's training program and existing regulations. Both had attended a crew resource management (CRM) course conducted by Transport Canada (TC) two weeks before the accident.

1.5.2 The Captain

The captain had been hired by the company in September 1998 and had completed a successful pilot proficiency check flight with a TC inspector on 20 October 1998. Except for a few minor items, the inspector noted that the pilot completed a well-flown check flight. After completing a line indoctrination of four flights, the captain was released to line operations. There was no record of subsequent checking of the captain's performance by either the company or TC. The captain was the most senior and experienced pilot based at Goose Bay.

1.5.3 The First Officer

The FO was hired on 02 November 1998 with approximately 400 total flying hours. This was his first job with a commercial air operator. He completed a successful pilot proficiency check on 18 November 1998. The TC inspector noted that he demonstrated acceptable proficiency for
FO duties on the Twin Otter.

1.6 Aircraft Information

Manufacturer	de Havilland Aircraft
Type and Model	DHC-6 Series 300 Twin Otter
Year of Manufacture	1984
Serial Number	724
Certificate of Airworthiness	25 October 1995
Total Airframe Time	30 490 hours
Engine Type (number of)	Pratt & Whitney PT6A-27 (2)
Propeller/Rotor Type (number of)	Hartzell HC-B3TN-3D (2)
Maximum Allowable Take-off Weight	12 500 pounds
Recommended Fuel Type(s)	Jet A, Jet A-1, Jet B
Fuel Type Used	Jet A-1

1.6.1 Additional Aircraft Data

The Twin Otter is a turbine-powered, short take-off and landing aircraft specifically designed to operate from relatively short, rough-surfaced runways. The aircraft was certified to operate in icing conditions; however, it is considered susceptible to ice-contaminated-tailplane stall (ICTS) under certain conditions. Consequently, the aircraft manufacturer has published specific operating instructions to be followed when operating in icing conditions in order to avoid ICTS.

These instructions specify that the flight crew ensure correct operation of the airframe de-icing system before extending wing flaps and that the wing flaps should not be set beyond 10 degrees while operating in icing conditions.

The aircraft was equipped for instrument flight rules (IFR) flight. A radio altimeter was included in the aircraft equipment. After the accident, the radio altimeter was found set to 1300 feet, which coincided with the MDA.

1.6.2 Aircraft Loading

The aircraft was loaded with cargo the night before the accident flight. On the morning of departure, passenger seats, apparently to be used for the return flight, were placed in the rear of the aircraft as cargo. The cargo's total weight entered in the journey logbook was 2739 pounds; cargo documents available only accounted for 2190 pounds. The only damage to the floor and side wall track, used to attach seats and/or cargo tie-down rings, was to the side wall track on the right side of the aircraft in the area where eight steel doors had been secured. The fact that the remainder of the floor and side wall track was undamaged, especially in the area where two 400-pound wood stoves had been placed in the aircraft, indicates that the remainder of the cargo had not been secured.

Personnel at the Goose Bay base lacked appreciation for the importance of correct loading and securement practices. The pilot-in-command (PIC) did not ensure that the cargo was properly loaded and safely secured. TC included a finding to this effect in its post-accident regulatory audit.

Refuelling records indicate that 2200 pounds of fuel was added to a calculated 320 pounds of fuel that was already on board the aircraft. This indicates the aircraft was fully fuelled with 2520 pounds of fuel. The journey logbook fuel on board entry shows a fuel weight of 2000 pounds for the accident flight. The aircraft operational empty weight was 7741 pounds. Adding the operational empty weight to the cargo's recorded weight (2739 pounds) and the calculated fuel load (2520 pounds), the total aircraft weight would have been 13 000 pounds. The maximum take-off weight for the Twin Otter is 12 500 pounds.

The company operations manual specifies that a copy of the weight and balance is to be left at the departure point, if practical. The crew had completed an operational flight plan, a copy of which was left at Goose Bay; however, no copy of the weight and balance form was found with this paper work. It was determined that it was normal for crews not to leave a copy of the weight and balance form at the departure point.

1.6.3 Ground Proximity Warning System

The occurrence aircraft had previously been fitted with a ground proximity warning system (GPWS); however, the system had been removed. Regulation only requires GPWS equipment to be installed in turbo-jet powered aircraft that are greater than 33 069 pounds maximum certified take-off weight and that have a type certificate authorizing the carriage of 10 or more passengers.

1.7 Meteorological Information

1.7.1 Area Forecast

The area forecast issued by Environment Canada for the area including Davis Inlet on 19 March 1999 at 1130 UTC, valid from 1200 to 2400 UTC (0800 to 2000 AST), contained the following information:

> A quasi-stationary north-northeast, south-southwest upper trough was situated 30 nm west of Goose Bay. Within 180 miles west of the trough, the sky conditions were expected to be 1500 to 3000 feet overcast, with cloud layers up to 13 000 feet and high broken cloud. The visibility was expected to be from 3 to more than 6 statute miles (sm) in light snow. Scattered embedded convective-type cloud was also expected to reduce visibility to between 0.25 and 3 sm in moderate or light snow, ice pellets, and blowing snow. Frequent stratus precipitation ceilings at 200 to 1000 feet were also forecast.

1.7.2 Aerodrome Forecast

An aerodrome forecast (TAF) was not available for Davis Inlet Airport.

A TAF issued for Nain, Newfoundland, which is approximately 45 nm northwest of Davis Inlet, for 1100 to 2300 UTC (0700 to 1900 AST) forecast a ceiling of 1500 feet overcast, visibility of 5 sm in light and blowing snow, and surface winds from 330 degrees true at 20 gusting to 30 knots.

The TAF for Goose Bay for 1000 to 1000 UTC (0600 to 0600 AST) predicted visual flight rules (VFR) conditions with temporary ceilings of 1000 feet overcast and visibility of one mile in light snow after 1600 UTC.

1.7.3 Weather Reports

The aviation routine weather report (METAR) for Nain at 1300 UTC (0900 AST) reported a ceiling of 2000 feet overcast and visibility of 10 sm in light and drifting snow. The surface winds were 330 degrees magnetic at 20 gusting to 25 knots. Weather received by the crew from the St. John's FSS while en route was consistent with this METAR.

METARs were not available for Davis Inlet; consequently, crews obtained actual weather information from local townspeople. The company had made arrangements several days before the accident to receive this information from a local resident; however, it could not be verified if weather for Davis was obtained before flight.

It was determined that the aircraft was operating in instrument meteorological conditions and icing conditions during both instrument approaches. During the second approach, the crew requested the local weather and were informed that the ceiling was 150 to 200 feet.

Another company aircraft conducted an approach and missed approach in the Davis Inlet area approximately one hour after the accident and subsequently diverted to Nain because the pilot did not see the landing area at MDA. The pilot of this aircraft encountered moderate, mixed icing conditions.

1.8 Aids to Navigation

There is one instrument approach for Davis Inlet, the non-directional beacon (NDB) A. This approach is based on the Davis Inlet NDB, which is south of the runway's extended centreline. The published instrument procedure is a circling approach. The MDA is 1340 feet asl (1295 feet above ground level), and the published advisory visibility is 3 sm. The approach procedure is to the north-northeast of the airport and, for the most part, over the ocean. The missed approach point is at the NDB (see Appendix C).

1.9 Communications

Communications between Speed Air 960 and Air Traffic Services were normal throughout the flight. Approximately 20 minutes before reaching Davis Inlet, the crew were in contact with company dispatch in St. John's via high frequency radio. Five minutes before arriving overhead the airport, the flight crew transmitted on the traffic advisory and the universal communications (UNICOM) frequencies their intentions to conduct the NDB A instrument approach at Davis Inlet.

1.10 Aerodrome Information

Davis Inlet is 155 nm north-northeast of Goose Bay. The airport, operated and maintained by the Government of Newfoundland and Labrador, is a certified aerodrome adjacent to the community. The airport identifier is CCB4, and the reference elevation is 45 feet asl. Runway 14/32 is gravel surface 2500 feet long by 75 feet wide. It is the only runway and is parallel with and adjacent to the shoreline.

1.11 Flight Recorders

The aircraft was equipped with a Loral cockpit voice recorder (CVR). This unit was recovered from the accident site and sent to the TSB Engineering Branch for analysis. It had recorded up to the point of impact; 32 minutes of good quality audio data were obtained.

The aircraft was not equipped with a flight data recorder, nor was one required by regulation.

1.12 Wreckage and Impact Information

The aircraft struck snow-covered ice on a heading of 222 degrees magnetic in a slightly nose-down, wings-level attitude. The wreckage trail was approximately 600 feet long by 180 feet wide: the nose landing gear was near the beginning of the trail; the instrument panel was at the end of the trail; and the fuselage, engines, left wing, empennage, and cargo were strewn along the trail between these points. The wreckage pattern observed was consistent with a controlled, shallow descent.

During the break-up, the cockpit was destroyed, and all of the cabin-area cargo exited through the front of the aircraft. The absence of damage to load securing attachment points and the absence of load restraining devices indicated that the load had not been restrained.

The electronic timer and the horizontal stabilizer distributor valve and pressure switch unit for the airframe de-icing system were removed and sent to the TSB Engineering Branch for examination. It was determined that these items were serviceable at the time of impact.

The right wing remained attached to the aircraft. Measurements were taken of the flap position on this wing in relation to a reference point on the fuselage. Measurements were also taken of the positions of the control rods attached to this flap. The flaps on an in-service aircraft were set to these measurements, and a flap angle of 14 degrees was recorded. The normal operating flap selections are 10, 20, and 40 degrees; these selections are to correspond to actual flap angles of 10, 20, and 37.5 degrees. Possible explanations for the flap position reading of 14 degrees are as follows:

- the flaps were in transit beyond 10 degrees at impact;
- erroneous measurements resulting from impact-related fuselage deformation;

- the flap selector lever was not aligned with the 10-degree position mark (there are no detents);

or

- rigging differences between the two aircraft.

During both approaches, the only flap positions selected by the crew were up or 10 degrees. Consequently, it is unlikely that the flaps were past 10 degrees; the post-impact flap position probably corresponds to the 10 degrees selected by the crew. The discrepancy is due to impact effects, rigging differences, and/or selector position.

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.

1.15 Survival Aspects

At the time of the accident, an airport employee heard a loud bang. He alerted others, and a ground search was initiated by the community in the direction of the approach path. The wreckage site was found a short time later. Both crew members had been thrown from the aircraft; the FO had been fatally injured, and the captain had sustained serious injuries. The captain's injuries were treated at the site and at the community clinic by a local nurse until he could be evacuated.

The aircraft's emergency locator transmitter (ELT) was rendered inoperative due to impact forces. However, this did not delay locating the aircraft because even if the ELT had activated, no equipment capable of homing in on the signal was available at Davis Inlet.

1.16 Tests and Research

No tests or research were conducted.

1.17 Organizational and Management Information

1.17.1 General

At the time of the accident, the company operated a diversified fleet of aircraft, including Twin Otter, Beechcraft King Air, Fairchild Metro, Piper Navajo, and Britten-Norman Islander aircraft. The Twin Otter and Metro III were operated as Interprovincial Airlines. The company's main base of operations was St. John's, and sub-bases were established in four cities: Halifax, Nova Scotia; Goose Bay, Newfoundland; Sault Ste. Marie, Ontario; and Vancouver, British Columbia.

The company held an air operating certificate issued by TC authorizing the operation of the Twin Otter aircraft in commercial air service for passenger and cargo carriage under IFR and night VFR. The aircraft was operated under Canadian Aviation Regulation (CAR) 704, Commuter Operations, and was dispatched under a Type C dispatch system. Under this system, the PIC is authorized to self-dispatch a flight.

1.17.2 Management

The company is privately owned. The operations manager and the director of maintenance report directly to the president, and the chief pilot reports directly to the operations manager. The chief pilot and the operations manager were directly involved with flight crew hiring and had hired the crew of the accident flight. The operations manager was responsible for ensuring that all flights were conducted in accordance with the company operations manual.

1.17.3 Goose Bay Operations

The company Twin Otter operation was based in Goose Bay. The Goose Bay operation was not identified as a sub-base in the air operating certificate or the company operations manual, nor was it required to be by regulation. Goose Bay company personnel consisted of a base manager, pilots, and maintenance staff. One of the base manager's duties was loading aircraft; he had loaded the accident aircraft the night before the departure.

On 02 February 1999, TC inspectors monitored the Twin Otter operation at Goose Bay. The monitoring consisted of one ramp check, which was conducted with the accident crew, and one in-flight inspection, which was conducted with two other Goose Bay pilots. No anomalies or deficiencies were identified.

1.18 Additional Information

1.18.1 Flight Planning

An IFR flight plan requires that an aircraft carry sufficient fuel to proceed to destination and then to a suitable alternate airport, plus reserve fuel (approach and missed approach fuel plus 45 minutes at normal cruise). The weather data the captain had received before departure showed that alternate airports were available. However, he departed under VFR and, when instrument meteorological conditions were encountered en route, he continued under the VFR flight plan.

CAR 602.115, Minimum Visual Meteorological Conditions for VFR Flight in Uncontrolled Airspace, states in part:

> No person shall operate an aircraft in VFR flight within uncontrolled airspace unless
> *(a)* the aircraft is operated with visual reference to the surface;
> (*b*) where the aircraft is operated at or above 1,000 feet AGL
> (i) during the day, flight visibility is not less than one mile,
> (ii) during the night, flight visibility is not less than three miles, and
> (iii) in either case, the distance of the aircraft from cloud is not less than 500 feet vertically and 2,000 feet horizontally;
> *(c)* where the aircraft is not a helicopter and is operated at less than 1,000 feet AGL
> (i) during the day, flight visibility is not less than two miles, except if otherwise authorized in an air operator certificate or a private operator certificate,
> (ii) during the night, flight visibility is not less than three miles, and
> (iii) in either case, the aircraft is operated clear of cloud; and . . .

VFR flights should be planned to avoid encountering weather that is below the requirement for the flight. CAR 602.72 requires that pilots be familiar with the available weather information that is appropriate for the flight. However, regulations do not preclude a pilot from filing a VFR flight plan with weather conditions that are forecast or reported to be below VFR minimums. In this occurrence, the weather en route was forecast to be below the requirements for VFR.

1.18.2 Standard Operating Procedures

CARs require that standard operating procedures (SOPs) be established and maintained for each aircraft type that will be flown with two or more pilots in a commercial operation. These procedures use the challenge-and-response method to ensure that important cockpit checks are conducted. SOPs were established and maintained by the Twin Otter aircraft operator. The company operations manual states that SOPs are a means of ensuring that

> . . . a high level of safety is achieved through crew co-ordination in the handling of routine and emergency situations. They include standard calls through altitudes, when instrument approach procedures will be reviewed, etc. No deviation from the procedures is acceptable unless the PIC determines that the safety of the flight may be compromised.

Some of the following Twin Otter SOPs were applicable to the occurrence flight:

> Approach briefing consisting of:
>
> a) ATS instructions
> 2. Approach in use
> b) Missed approach (including obstacle clearance)
> c) Flap setting V_{ref} (confirm landing weight)
>
> Timing:
>
> With respect to timing on Non-Precision Approaches, Holds, and Procedure Turns, the PF will request the PNF [pilot not flying] to start his time precisely at that instant by stating "Start Time Now", at which time the PNF will start the clock for the specific manoeuvre.
>
> Approach:
>
> The approach check shall be initiated and the aircraft configured at approximately five miles from the airport facility. The PF calls for the "Approach Checklist" and the PNF actions the approach checklist, calls "Approach Checklist Complete" and "Landing Checklist Next".

Non-Precision Approach Procedure:

	PF	PNF
After completion of procedure turn:	-Commands "Flap 10°"	-Confirms V_{fe}, sets and calls "Flap 10° set"
Approximately one mile from final approach fix on final track:	-Calls "Landing checklist"	-Actions checklist items
	-Responds to checklist	-Calls "Landing checklist complete"
Overhead final approach fix:	-Commands "Start time"	-Calls "Timer Started", "Altimeters cross checked"
		-Calls "1000 Above"
	-Responds "Check no flags"	-Calls "500 Above"
	-Responds "Check"	-Calls "100 Above"
	-Responds "Check"	
At MDA:		-Calls "Minimums ... Seconds to Go" and visual cues (ie. approach lights)
	-Responds "Check MDA" increase power to maintain level flight	
At missed approach point:		-Calls "Time is up" and visual cues or "Negative contact"
	-Responds "Landing" or "Go-around"	

Very few of the required SOP calls were made, and the approach briefing and the approach and landing checks were not conducted. Only one call through an altitude was made during the initial approach; no calls through altitudes were made on the second approach. There was no indication that the crew were aware of their altitude until shortly before the point of impact.

1.18.3 Crew Resource Management

CRM training is a requirement for CAR 705 (airline) operations. Although CRM training is not required for CAR 704 (commuter) operations, both crew members had received this training from TC two weeks before the accident. The application of CRM concepts can improve crew performance through enhanced communication, problem solving, decision making, and workload management.

The captain had significant overall flying experience and approximately 2500 hours on the Twin Otter. The FO had relatively little flying experience and very little experience on the Twin Otter. Studies have shown that inappropriate pairings of pilots (according to experience levels and personality traits) have been contributing factors in aircraft accidents.[4] The practice of CRM should reduce this risk. The captain frequently disregarded SOPs and either discouraged or ignored inputs and prompts from the FO on the conduct of the flight, indicating that important CRM concepts were not being applied.

1.18.4 Controlled Flight into Terrain

Controlled flight into terrain (CFIT) accidents are accidents in which an aircraft, capable of being controlled and under the control of the crew, is flown into the ground, water, or obstacles with no prior awareness on the part of the crew of the impending collision. Although CFIT accidents occur in all phases of flight, most occur during the approach and landing phase of flight. A study by the Flight Safety Foundation Approach-and-Landing Accident Reduction (ALAR) Task Force identified causes of and contributing factors to CFIT accidents in approach and landing occurrences.[5] The most common causes and contributing factors are the following:

- Poor professional judgement:
  Not executing a missed approach in the absence of visual cues;

- Omission of action / inappropriate action:
  Omission of approach briefing or altitude call outs; failure to check the radio altimeter; failure to call out "runway in sight / no contact" at MDA; and omission of checklist items;

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[4] Earl L. Wiener and David C. Nagel, *Human Factors in Aviation,* San Diego, California: Academic Press, 1988; David O'Hare and Stanley Roscoe, *Flightdeck Performance: The Human Factor,* Ames, Iowa: Iowa State University Press, 1990; System One Learning Services and Transport Canada, *Cockpit Resource Management: A Vital Element in Aviation Safety and Flight Deck Effectiveness.*

[5] *Flight Safety Digest,* November–December 1998 and January–February 1999.

- Failure in CRM:
  Continuing an approach in adverse conditions; descent below MDA/DH [decision height] prior to acquiring visual cues in whiteout conditions; absence of standard call outs and briefings; and failure to recognize deviations from standard/approved procedures. Failures in CRM may be associated with complacency and overconfidence, high workloads, cultural influences, and a lack of risk assessment; and

- Lack of positional awareness:
  Lack of vertical position awareness resulting in CFIT.

It should also be noted that 75 per cent of aircraft involved in the ALAR study were not equipped with a GPWS.

2.0 Analysis

2.1 General

Nothing was found during the investigation to suggest mechanical failure of any part of the aircraft that would have caused or contributed to the accident. Therefore, the analysis will examine ICTS, aircraft loading, company SOPs, company management, flight crew decision making, GPWS, and CFIT.

2.2 Ice-Contaminated-Tailplane Stall

During both approaches, the aircraft was operating in icing conditions. If a sufficient amount of ice accumulates on the tailplane with certain aircraft configurations, ICTS can occur. The tail de-icing system functioned normally during the flight. It was determined that the crew had set the flaps to 10 degrees, which indicates that the recommended ICTS prevention procedures were being followed. Had ICTS occurred, the aircraft would have struck the ice in a steep nose-down attitude rather than a shallow impact angle, as in this accident. Therefore, it is concluded that the tailplane did not stall.

2.3 Aircraft Loading

A copy of the weight and balance worksheet was not left at the departure point, nor was the worksheet found at the accident site. Therefore, it could not be established whether the aircraft's weight and balance contributed to the accident.

The lack of available documentation, the apparent lack of appreciation displayed by company personnel regarding the importance of safely securing cargo, and the inadequate security of the cargo indicate that the company's load control procedures were not being followed.

Improperly restrained cargo can be hazardous since cargo movement can alter the aircraft's centre of gravity or cause injury to passengers or crew. There was no indication that the cargo moved in flight.

2.4 Standard Operating Procedures

The crew did not comply with the company operations manual's SOPs, thus increasing their exposure to risk during the flight. Non-adherence to SOPs is recognized as a frequent causal factor in approach and landing accidents. In this flight, SOPs, especially altitude calls, would have heightened the crew's awareness about their proximity to terrain.

2.5 Management

There was no weight and balance documentation left at the departure point, which was determined to be a normal company/pilot practice, and the cargo was not properly secured before take-off. Because there was a company manager in Goose Bay to oversee the operation and to carry out or assist in aircraft loading, it is likely that the company allowed unsafe aircraft loading procedures to be followed at Goose Bay. In addition, operating the aircraft in instrument meteorological conditions under a VFR flight plan contravened the company operations manual and CAR 602.115. Such lapses by the Goose Bay operation's management were not detected by TC safety monitoring or other oversight activities.

2.6 Decision Making

2.6.1 Crew Resource Management

Effective CRM enhances decision making and improves situational awareness. Both pilots had received CRM training 12 days before the accident; however, CRM techniques were not evident in their performance on the accident flight.

2.6.2 Descent Below Minimum Descent Altitude

Before the second approach, the captain made a decision to descend below the MDA if visual contact with the ground was established. The aircraft did descend below MDA and struck the ground. Reports of weather conditions on the ground at the airport and the crew not acquiring the required references at MDA on the first approach indicate that the crew did not have the necessary references for descent below MDA on the second approach. The crew were preoccupied with gaining visual reference during the descent and did not adequately monitor the aircraft flight instruments. Consequently, they were unaware of their proximity to the terrain.

2.7 Terrain Warning Equipment

The accident aircraft was not equipped with a GPWS, which is designed to provide a positive warning of approach to terrain. An operable GPWS would have assisted in restoring the crew's situational awareness by providing them with appropriate advisories and cues about their proximity to terrain and would have reduced the likelihood of this accident occurring.

Although GPWS equipment is required on larger, passenger-carrying jet aircraft, the requirement does not extend to cargo operations, even though these operations are often conducted visually in remote areas.

GPWS equipment is a recognized defence against CFIT accidents, and the absence of GPWS has been recognized by the Board as a contributory factor for approach and landing accidents.

2.8 Controlled Flight into Terrain

Several of the most common factors found in other CFIT accidents were present in this occurrence. The crew did not execute a missed approach in the absence of visual cues or follow SOPs (omitted approach briefing, altitude call outs, appropriate call at MDA, and checklist items). Furthermore, they continued the approach below MDA without acquiring the necessary visual references. The absence of CRM and non-adherence to SOPs removed important defences in preventing CFIT.

In this occurrence, the aircraft was capable of being controlled and was under the control of the crew until impact. Nothing indicated that the crew were aware of their proximity to the ice until shortly before impact. Consequently, this is considered to be a CFIT accident.

3.0 Conclusions

3.1 Findings as to Causes and Contributing Factors

1. The captain decided to descend below the minimum descent altitude (MDA) without the required visual references.

2. After descending below MDA, both pilots were preoccupied with acquiring and maintaining visual contact with the ground and did not adequately monitor the flight instruments; thus, the aircraft flew into the ice.

3.2 Findings as to Risk

1. The flight crew did not follow company standard operating procedures.

2. Portions of the flight were conducted in areas where the minimum visual meteorological conditions required for visual flight rules flight were not present.

3. Although both pilots recently attended crew resource management (CRM) training, important CRM concepts were not applied during the flight.

4. The cargo was not adequately secured before departure, which increased the risk of injury to the crew.

5. The company manager and the pilot-in-command did not ensure that safe aircraft loading procedures were followed for the occurrence flight.

6. There were lapses in the company's management of the Goose Bay operation; these lapses were not detected by Transport Canada's safety oversight activities.

7. The aircraft was not equipped with a ground proximity warning system, nor was one required by regulation.

8. Records establish that the aircraft departed approximately 500 pounds overweight.

3.3 Other Findings

1. The flight crew were certified, trained, and qualified to operate the flight in accordance with existing regulations and had recently attended CRM training.

2. During both instrument approaches, the aircraft was operating in instrument meteorological conditions and icing conditions.

3. There was no airframe failure or system malfunction prior to or during the flight. In particular, the airframe de-icing system was serviceable and in operation during both approaches.

4. It was determined that an ice-contaminated tailplane stall did not occur.

5. The fuel weight was not properly recorded in the journey logbook.

6. The wreckage pattern was consistent with a controlled, shallow descent.

7. The emergency locator transmitter was damaged due to impact forces during the accident, rendering it inoperable.

4.0 Safety Action

4.1 Action Taken

After the accident, Transport Canada (TC) conducted a regulatory audit of the operator and increased the frequency of in-flight checks and general inspection of the Goose Bay operation.

4.2 Action Required

Regulatory Safety Oversight

This occurrence investigation uncovered several serious deficiencies in the conduct of the mission. These deficiencies could be symptomatic of a broader and ongoing disregard for regulations and company standard operating procedures (SOPs). Indicators of the deficiencies are as follows: the presence of poor company loading practices at Goose Bay; inadequate company supervision of the Goose Bay operation; non-adherence to aircraft SOPs; and deliberate operation of the aircraft below the minimum descent altitude (MDA) when adequate visual references for landing were not present. These deviations from normal practices were present in day-to-day operations.

The TSB has observed similar deficiencies in the conduct of business in other organizations, as demonstrated by the occurrences referenced in Appendix A—Supporting Documentation to Section 4.2. Common findings relating to regulatory oversight in these accidents, in general terms, were as follows:

- descent below MDA without adequate visual references;
- non-adherence to SOPs;
- operating under visual flight rules when in instrument meteorological conditions;
- operating the aircraft in an overweight condition; and
- inadequate company supervision of operations or maintenance.

Generally, these accidents have been with smaller commercial operators or during operations in remote areas where oversight is difficult. In these operations, there were clear indications that a culture was allowed to exist in which crews and operators operated outside the safety regulations, with catastrophic consequences.

It is recognized that effective safety oversight of smaller or remote operations is a challenging task. Notwithstanding this challenge, the level of acceptable risk should not be greater for passengers and crews who fly on aircraft operated by smaller operators or who operate in or into remote areas, simply because oversight is difficult. It is also recognized that there have been initiatives undertaken by TC to reduce the level of risk in these operations. However, these and other accidents indicate that more needs to be done. It appears that the traditional methods of inspection, audit, general oversight, and regulatory penalties have had limited success in fostering appropriate safety cultures in some companies and individuals; consequently, unsafe conditions continue to exist and unsafe acts are still being committed.

These serious accidents indicate that some operators and crews have disregarded safety regulations and, consequently, put passengers and themselves at an unnecessary and unacceptably high level of risk. In these accidents, findings indicate that, in certain areas of commercial operations, the safety oversight efforts of TC have been somewhat ineffective. Therefore, the Board recommends that:

> The Department of Transport undertake a review of its safety oversight methodology, resources, and practices, particularly as they relate to smaller operators and those operators who fly in or into remote areas, to ensure that air operators and crews consistently operate within the safety regulations.
>
> A01-01

This report concludes the Transportation Safety Board's investigation into this occurrence. Consequently, the Board authorized the release of this report on 09 May 2001.

Appendix A—Supporting Documentation to Section 4.2

A00H0001 — The Piper Navajo Chieftain PA-31-350, with one pilot and six passengers on board, was attempting to land at Stony Rapids, Saskatchewan. The pilot had conducted a non-directional beacon (NDB) approach at night in Stony Rapids, followed by a missed approach. He then attempted and missed a second approach and followed this with an attempted visual approach. While manoeuvring to land on runway 06, the aircraft struck trees 3.5 nautical miles west of the button and roughly one quarter nautical mile left of the runway centreline. The aircraft sustained substantial damage, but no fire ensued. The pilot and one passenger were seriously injured, and the remaining five passengers sustained minor injuries.

Significant and relevant findings in this occurrence

- The pilot executed a missed approach on his first NDB approach. During the second missed approach, after momentarily seeing the runway, he decided to conduct a visual approach, descending below minimum descent altitude (MDA) in an attempt to fly under the cloud base.

- The maximum allowable take-off weight of the aircraft was exceeded by about 115 pounds.

A99Q0005 — The Régionnair Inc. Beechcraft 1900C, with two pilots and 10 passengers on board, was conducting a LOC/DME (localizer transmitter / distance-measuring equipment) non-precision approach for runway 20 at Saint-Augustin, Quebec. The crew had been informed that the ceiling was 300 feet, visibility was a quarter of a mile in snow flurries, and the wind was from the southeast at 15 knots gusting to 20 knots. The MDA and the advisory visibility for the approach were 500 feet (483 feet above the runway) and one and a half miles. The aircraft flew into the frozen surface of the Saint-Augustin River and was heavily damaged. The occupants escaped the accident unharmed. The investigation did not reveal any deficiency or malfunction of the aircraft's systems and components that might have contributed to the occurrence.

Significant and relevant findings in this occurrence

- The captain (chief pilot) set a bad example to the pilots under him by using a dangerous method, that is, descending below the MDA without establishing visual contact with the required references and using the ground proximity warning system (GPWS) to approach the ground.

- The crew did not follow the company's standard operating procedures for the briefing preceding the approach and for a missed approach.

- The GPWS "MINIMUMS" alarm sounded at a height that did not leave the captain time to initiate pull-up and avoid striking the ground because of the aircraft's rate of descent and other flight parameters.

A98Q0007 — The Piper Navajo Chieftain PA31-350 was on an instrument flight rules flight from Sanikiluaq to Iqaluit, Northwest Territories. Two pilots and two passengers were on board. After checking the runway condition and weather, the pilot commenced his take-off run on runway 27. After take-off, the pilot saw flames coming out of the right engine cowl. The right engine was shut down, but the aircraft could not maintain a sufficient rate of climb. The aircraft crashed on flat, snow-covered ground about one mile from the end of the runway, sustaining substantial damage on impact. No injuries occurred. The occurrence happened at night in instrument meteorological conditions.

Significant and relevant findings in this occurrence

- The aircraft exhaust system was modified in contravention of the manufacturer's recommendations and the regulations.

- The company had three different Directors of Maintenance in 1997. That position was vacant on the day of the accident.

- An inspection of the records and the files for the aircraft revealed several deficiencies in records management.

- The persons in charge of maintenance authorized the aircraft to be used while deficiencies had not been corrected.

- TC had not made regular audits of the company since 1992.

- Only one review of the maintenance department was conducted, in September 1994. The last review of the maintenance department was conducted after the accident, in February 1998, and several deficiencies concerning the maintenance department and the company were found; the review resulted in the suspension of the company operating certificates.

A97C0236 — The Sowind Air Ltd. Embraer EMB-110P1 Bandeirante aircraft departed the operator's base at St. Andrews, Manitoba, with two crew member and 15 passengers, on a 40-minute, scheduled flight to Little Grand Rapids. The crew flew an instrument approach to the Little Grand Rapids airport and executed a missed approach because the required visual reference was not established. A second instrument approach was attempted. The aircraft was observed very low over the lake to the south of the airport and to the east of the normal approach path. Passengers in the aircraft also indicated they were very low over the lake and to the east of the normal approach path. The passengers described an increase in engine power followed by a rapid series of steep, banking manoeuvres after the aircraft crossed the shoreline to the southeast of the airport. During the manoeuvres, the aircraft descended into the trees and crashed approximately 400 feet south and 1600 feet east

of the approach to runway 36. The captain and 3 passengers were fatally injured; the first officer and the remaining 12 passengers were seriously injured.

Significant and relevant findings in this occurrence

- The aircraft was flown in marginal weather at low level, below the minimum en route altitude for commuter operations and below the MDA for the NDB A approach at Little Grand Rapids. The MDA for the approach was 1560 feet above sea level, 555 feet above the airport elevation.

- At take-off and at landing, the aircraft was about 1000 pounds heavier than the relevant maximum allowable weight.

- The weight and balance report that was submitted to TC, required for the importation of C-GVRO, contained numerous discrepancies. The report was not reviewed for accuracy by TC.

- The company, which had been an air taxi operator, did not effectively manage either the addition of the more complex commuter operations or the introduction of the larger Bandeirante aircraft.

- The difficulty that the company had in the transition to commuter operations and in the introduction of the Bandeirante aircraft was underestimated by TC.

- There were inadequacies in TC's oversight, whereby the post-certification audit of the company was not conducted (thus eliminating an important mechanism by which TC could have found and addressed the inadequate safety management practices), non-conformance with pilot training requirements, and related operating irregularities.

- The pilots had passed their flying proficiency and medical tests, but they had not completed elements of pilot training requirements concerning servicing and operational control and right-seat conversion as prescribed by TC. Also, no company pilot had received required training in the use of on-board survival or emergency equipment.

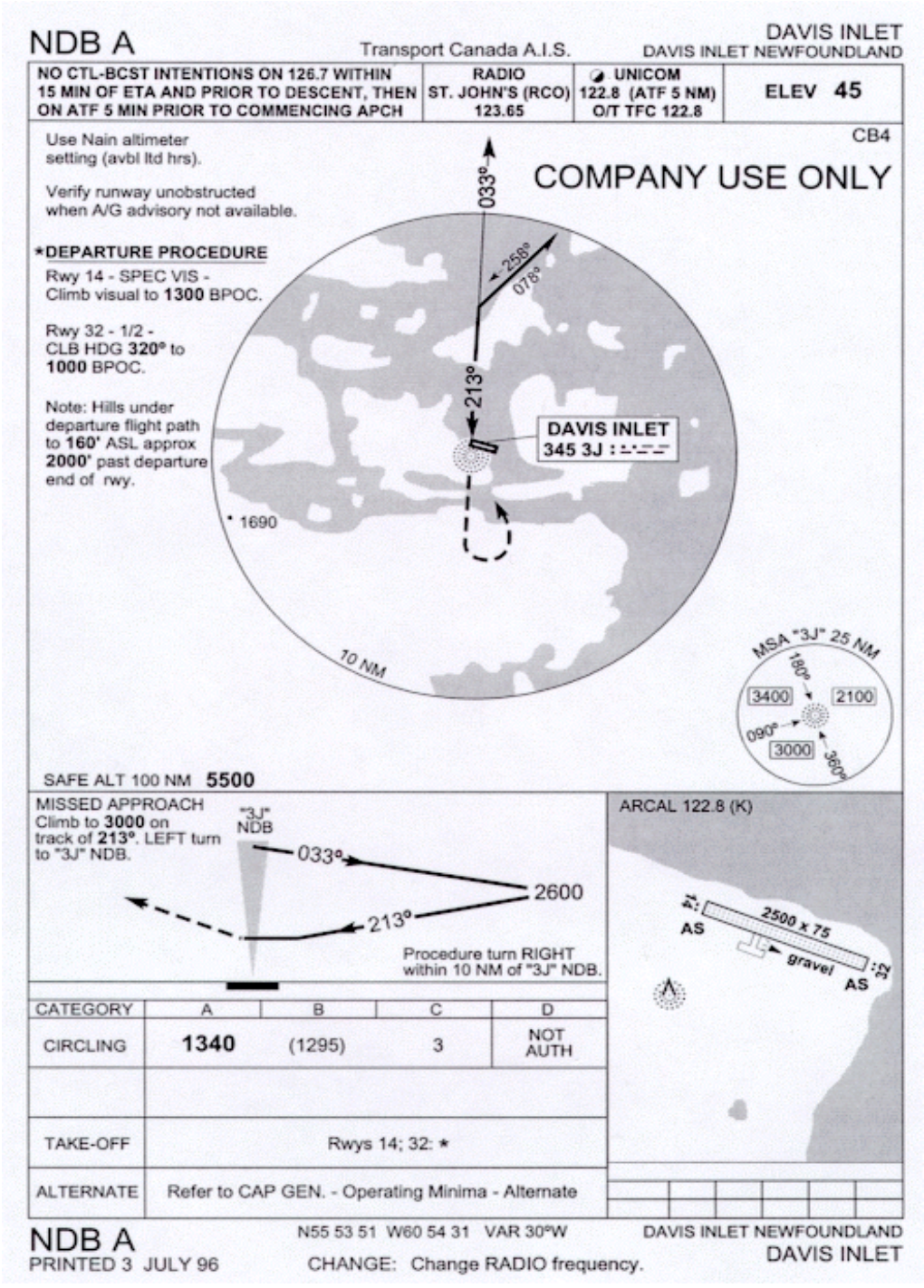
A97P0207 — The pilot of a Bell 206B helicopter was engaged in transporting survey crews in the Bear Valley, British Columbia, area. On the morning of the accident, he had begun flying at about 0645 Pacific daylight time. A survey crew contacted the pilot by radio at about 1200 and requested a pick-up for about 1400; they also informed him of a 100- to 150-foot ceiling and a visibility of about 300 metres (1000 feet). At about 1445, the pilot was attempting to locate the survey crew at the 5100-foot elevation, but low cloud, fog, and precipitation prevented him from making visual contact with the landing area. The pilot was in two-way radio contact with the ground crews and remarked that the lower pick-up pad was fogged in and that he could not see the trees or the ground below him. The pilot continued manoeuvring in the area, searching for the landing pad. The helicopter appeared from the base of the low cloud, in a right-hand, descending turn, roughly in a 40-degree nose-down and 40-degree right-bank attitude before it struck trees and collided with the terrain at 5200 feet above sea level, inside a cirque. The pilot was fatally injured, and the helicopter was destroyed by impact forces and a post-impact fire.

Significant and relevant findings in this occurrence

- The weather was such that the flight could not likely be completed in visual meteorological conditions.
- The pilot's work/rest schedule increased the probability of him making fatigue-related errors.
- According to company records, the pilot had, on several occasions, exceeded the legislated flight- and duty-time limitations of the *Canadian Aviation Regulations*.
- TC audits carried out after the accident revealed deficiencies in the company's control of maintenance and operational activities.
- Following the 1992 TC audit, deficiencies related to the company's air operator certificate and the approved maintenance organization certificate were either not eliminated or were allowed to re-emerge.
- The pilot did not hold an instrument rating.

Appendix B—Accident Site

Appendix C—Davis Inlet Approach Plate



Appendix D—List of Supporting Reports

The following TSB Engineering Laboratory Reports were completed:

LP 033/99—CVR Analysis
LP 102/99—Deicer Timer / Distributor Valve Examination.

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

Appendix E—Glossary

AGL	above ground level
ALAR	approach-and-landing accident reduction
asl	above sea level
AST	Atlantic standard time
ATPL	airline transport pilot licence
ATS	Air Traffic Services
CARs	Canadian Aviation Regulations
CFIT	controlled flight into terrain
CPL	commercial pilot licence
CRM	crew resource management
CVR	cockpit voice recorder
ELT	emergency locator transmitter
FO	first officer
FSS	flight service station
GPWS	ground proximity warning system
ICTS	ice-contaminated-tailplane stall
IFR	instrument flight rules
MDA	minimum descent altitude
METAR	aviation routine weather report
NDB	non-directional beacon
nm	nautical mile(s)
NNE	north-northeast
PF	pilot flying
PIC	pilot-in-command
PNF	pilot not flying
sm	statute mile(s)
SOPs	standard operating procedures
TAF	terminal area forecast (aerodrome forecast)
TC	Transport Canada
TSB	Transportation Safety Board of Canada
UNICOM	universal communications
UTC	Coordinated Universal Time
V_{fe}	maximum flap extended speed
VFR	visual flight rules
V_{ref}	landing reference speed
°	degree(s)