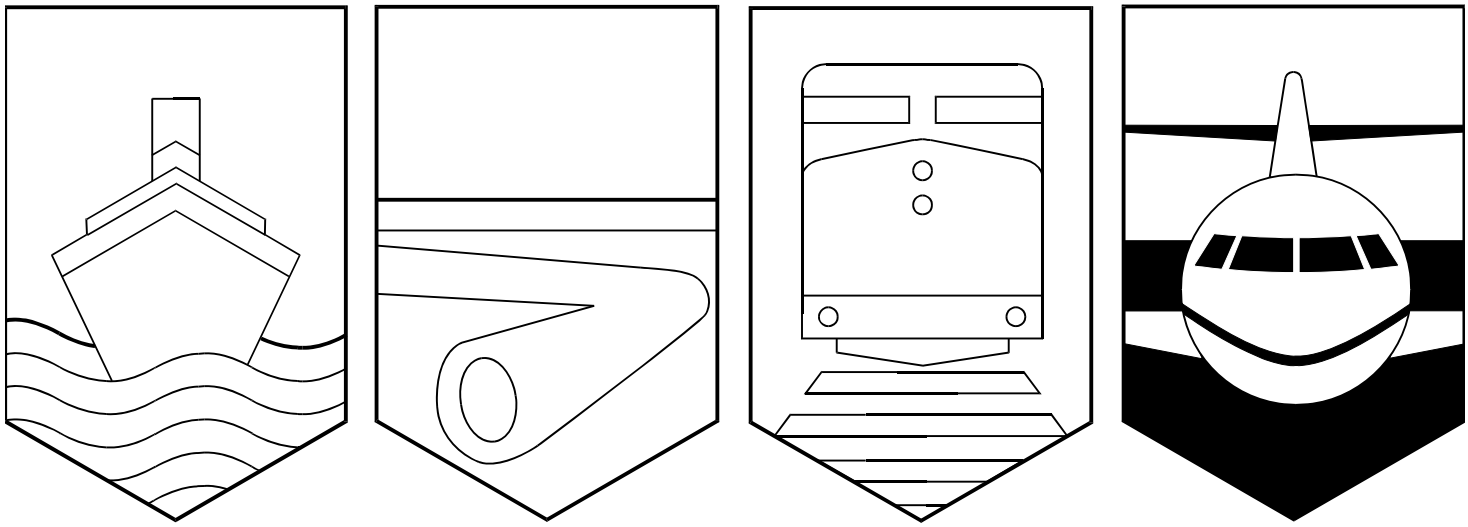
Transportation Safety Board of Canada

Bureau de la sécurité des transports du Canada



AVIATION OCCURRENCE REPORT

VFR FLIGHT INTO ADVERSE FLIGHT CONDITIONS

HÉLI-HARRICANA INC.
EUROCOPTER AS350B ÉCUREUIL (HELICOPTER) C-FPHI
KUUJJUAQ, QUEBEC 38 mi NE
24 SEPTEMBER 1994

REPORT NUMBER A94Q0182

Canada

MANDATE OF THE TSB

The Canadian Transportation Accident Investigation and Safety Board Act provides the legal framework governing the TSB's activities. Basically, the TSB has a mandate to advance safety in the marine, pipeline, rail, and aviation modes of transportation by:

- conducting independent investigations and, if necessary, public inquiries into transportation occurrences in order to make findings as to their causes and contributing factors;
- reporting publicly on its investigations and public inquiries and on the related findings;
- identifying safety deficiencies as evidenced by transportation occurrences;
- making recommendations designed to eliminate or reduce any such safety deficiencies; and
- conducting special studies and special investigations on transportation safety matters.

It is not the function of the Board to assign fault or determine civil or criminal liability. However, the Board must not refrain from fully reporting on the causes and contributing factors merely because fault or liability might be inferred from the Board's findings.

INDEPENDENCE

To enable the public to have confidence in the transportation accident investigation process, it is essential that the investigating agency be, and be seen to be, independent and free from any conflicts of interest when it investigates accidents, identifies safety deficiencies, and makes safety recommendations. Independence is a key feature of the TSB. The Board reports to Parliament through the President of the Queen's Privy Council for Canada and is separate from other government agencies and departments. Its independence enables it to be fully objective in arriving at its conclusions and recommendations.

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Synopsis

The pilot of the helicopter had taken off from a fishing camp on George River, Quebec, on a night visual flight to Kuujjuaq, Quebec, 94 statute miles to the west-southwest. The flight was a medical evacuation (MEDEVAC) in response to a medical emergency, to transport a seriously injured woman. When the aircraft did not arrive at its destination at the expected time, a search was begun. The helicopter was found five days later; it had struck the ground in a steep dive. The four occupants were killed instantly.

The Board determined that, while on a night MEDEVAC flight, the pilot likely lost his spatial orientation when he continued the flight in adverse flight conditions which he was not able to recognize in time because of the low light level. Contributing factors to the accident were that the pilot was not qualified for night flight or for instrument flight, and that the patient's condition likely influenced the pilot's decision to undertake the return night flight to Kuujjuaq for humanitarian reasons.

Ce rapport est également disponible en français.

Table of Contents

5.0 Appendices

1.0 Factual Information

1.1 History of the Flight

On 24 September 1994, an AS 350B helicopter belonging to Héli-Harricana, registration C-FPHI, left Kuujjuaq (CYVP), Quebec, at 1801 eastern daylight saving time (EDT)[1] on a visual flight rules (VFR)[2] flight. In response to a medical emergency, the pilot took a physician and a nurse from Kuujjuaq to a fishing camp on George River, 94 statute miles (miles) east-northeast of Kuujjuaq. The planned flight route involved flying over an area of tundra that is largely uninhabited. The helicopter landed at its destination in daylight at 1840.

After the patient had been examined, the aircraft, with the pilot, a physician, a nurse and the patient on board, took off at about 1900 for Kuujjuaq under visual flight rules. At 1915, the crew of a First Air Boeing 727, FAB 867, relayed a message to the Kuujjuaq Flight Service Station (FSS) that the helicopter pilot expected to land in Kuujjuaq at 1955. At 1936, the pilot of C-FPHI informed the Kuujjuaq FSS that he was 42 miles from the airport and was delaying his arrival time to 2005. The FSS specialist gave him the weather information for Kuujjuaq, and the pilot acknowledged receipt of the information. That was the last communication received from the pilot.

When the helicopter did not arrive at its destination at the expected time, a search was begun. The helicopter was found five days later; it had struck the ground in a steep dive, and had been destroyed by the impact. The crash occurred 38 miles northeast of Kuujjuaq, 2 miles south of the planned route. The pilot and the passengers died in the crash.

The accident occurred at about 1939, in darkness, at latitude 53°13'N and longitude 67°22'W[3]. Night had fallen at 1907.

1.1.1 Additional Operational Information

At about 1600 on 24 September 1994, a physician who was at Kangiqsualujjuaq (George River) was informed by radio that a woman had been seriously injured in a fishing accident two hours earlier.

After assessing the injured person's condition through an intermediary, the physician judged it necessary to have her evacuated. He contacted the flight dispatcher of Johnny Mae Air Charters in Kuujjuaq to charter a float plane. The pilot of the aircraft declined the mission because it was not possible to complete the flight before nightfall. At about 1715, the flight dispatcher reached the pilot of C-FPHI, the accident helicopter, who agreed to make the flight.

1.1.2 Flight Planning

The pilot and the flight dispatcher from Johnny Mae Air prepared an evacuation plan with two options. The first was to transport the patient to Kuujjuaq, if the flight could be completed before nightfall. The second option was to evacuate the injured woman to Kangiqsualujjuaq, where a twin-engined aircraft

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

2 See Glossary for all abbreviations and acronyms.

3 Units are consistent with official manuals, documents, reports, and instructions used by or issued to the crew.

equipped and certified for night flight and instrument flight would take her to Kuujjuaq. The pilot decided to go to the fishing camp before deciding which option to take.

The pilot went to Kuujjuaq airport at about 1730 to prepare the aircraft. The front left seat of the aircraft was removed and a hospital stretcher installed, and the medical equipment was placed on board. The helicopter took off with 3.4 hours of fuel on board. The pilot did not ask for a weather briefing or file a flight plan or flight notification with the FSS.

The pilot did not report any anomaly on arrival at the fishing camp. He did mention to a witness that he would be going to Kangiqsualujjuaq if the flight could not be completed in daylight. A little later, after a brief conversation with the physician, he said that he was leaving for Kuujjuaq.

The injured woman was held onto the stretcher by three straps. She was resting on the floor of the helicopter to the pilot's left, with her head to the back and her feet forward. The pilot occupied the front right seat, the physician the centre back seat, and the nurse the right back seat.

1.2 Injuries to Persons

	Crew	Passengers	Others	Total
Fatal	1	3	-	4
Serious	-	-	-	-
Minor/None	-	-	-	-
Total	1	3	-	4

1.3 Damage to Aircraft

The aircraft was destroyed.

1.4 Other Damage

The other damage was limited to the trees and the ground at the accident site.

1.5 Personnel Information

1.5.1 General Information

	Pilot-in-Command
Age	38
Pilot Licence	Commercial
Medical Expiry Date	01 Dec 94
Total Flying Hours	8,204.4
Hours on Type	2,133.2
Hours Last 90 Days	101.1

	Pilot-in-Command
Hours on Type Last 90 Days	80
Hours on Duty Prior to Occurrence	4.5
Hours Off Duty Prior to Work Period	23

1.5.2 Pilot Qualifications

The pilot had obtained a commercial pilot licence (helicopter) on 08 March 1979. He was authorized to fly VFR in daylight only. He had passed a pilot proficiency check (PPC) on 01 June 1994. Before July 1987, candidates for commercial pilot licences (helicopter) did not have to carry out 10 hours of dual control instrument flight as has been required since that date. Pilots of helicopters and small aircraft are not required to demonstrate their instrument flight ability during the PPC.

1.5.3 Night Flying

In daylight VFR, pilots rely on the presence of visual references outside the cockpit. Special piloting skills, different from those for visual flight, are required when those references are obscured. A night flight endorsement gives pilots the privilege of flying VFR at night. To obtain that endorsement, pilots must have taken a five-hour night course in a dual-control aircraft and must have flown five hours at night as pilot-in-command. Also, in order to prepare them for the possibility that they might inadvertently find themselves in instrument flight conditions (IMC), pilots must have received at least ten hours of training on basic instrument flight rules (IFR) flight manoeuvres.

1.5.4 Flying Experience

The pilot had extensive experience on several helicopter types. He was familiar with the region in which the accident occurred. Nothing in his file indicates that he was in the habit of flying in visibility conditions lower than those prescribed by the existing regulations.

The pilot's log-book, notebook, and personal files were used to assess his experience. The available information indicates that he had never been trained for either night flight or instrument flight.

Thirteen days before the accident, on 11 September 1994, the pilot had made a return flight from Kuujjuaq to Kangiqsualujjuaq. He had left Kuujjuaq at 1747 and had returned at 1950, six minutes after the end of dusk.

1.5.5 Additional Training

On 13 December 1988, the pilot had obtained a Transport Canada (TC) certificate stating that he had completed a course on pilot decision-making. The "Pilot Decision-Making Training Program (PDP)" was developed by TC to improve pilots' judgment through training.

In February 1989, when he was employed by Hélicoptères Nordic Ltée, the pilot had taken a company air safety officer course. The objective of this course was to train company pilots in the principles of managing air safety, so that companies could develop internal accident prevention programs.

1.5.6 Other Responsibilities

The pilot had been hired by Héli-Harricana because he had extensive experience in helicopter flight and had also worked for a number of years in the sub-Arctic coastal zone of northern Quebec.

The company had deployed two helicopters at Kuujjuaq at the beginning of the summer in order to develop a market in the region. Flights were carried out exclusively on an *ad hoc* basis. Although Kuujjuaq was not a Héli-Harricana base and the base manager duties were not defined, the pilot was acting as base manager. He was responsible for the proper operation of the company's affairs in the region.

1.6 Aircraft Information

1.6.1 General Information

Manufacturer	Aerospatiale
Type	AS 350B
Year of Manufacture	1980
Serial Number	1228
Certificate of Airworthiness (Flight Permit)	Valid
Total Airframe Time	4,297.9 hr
Engine Type (number of)	Turbomeca
Propeller/Rotor Type (number of)	Hingeless/3-Bladed/Composite
Maximum Allowable Take-off Weight	4,299 lb
Recommended Fuel Type(s)	Jet B
Fuel Type Used	Jet B

The single-engine, single-rotor helicopter was equipped with skids. C-FPHI was equipped with a global positioning system (GPS), a navigational device that can lighten a pilot's workload. The GPS data, including headings, speeds, times, ground speed, and so on, could be displayed on that instrument. The helicopter had neither an automatic pilot nor a stability augmentation system.

1.6.2 Helicopter Certification

The aircraft was certified, equipped, and maintained in accordance with the existing regulations and approved procedures. The helicopter had the instruments necessary for IFR flight. However, this type of helicopter was not certified for IFR flight. According to Air Navigation Order, Series VII, No. 6, no air carrier shall operate a single-engined rotorcraft in IFR flight or at night when carrying passengers.

1.7 Meteorological Information

The Board has conducted a study of VFR flight safety in adverse weather conditions[4]. The accident data make it possible to establish a direct connection between weather briefings and accident sites:

> "helicopter accidents ... occurred in sparsely settled areas to experienced pilots who often did not have access to, or did not avail themselves of, weather briefing facilities."[5]

A weather briefing in preparation for a flight is indispensable before departure, especially at night when the ambient light level prevents a pilot from detecting the presence of adverse weather conditions before encountering them.

1.7.1 Meteorological Information Available at Kuujjuaq Airport

An FSS staffed with FSS specialists was located at Kuujjuaq airport. The available services included:

- en route flight information service;
- flight planning service;
- surface weather observation service; and
- navigation assistance service.

Contrary to his custom, the pilot did not use the weather facilities available to him and did not request a weather briefing before the flight. There is nothing in regulations that specifically obliges a pilot leaving on a VFR flight to obtain a weather briefing. Shortly after the take-off from Kuujjuaq, the FSS specialist transmitted to him the weather conditions in Kangiqsualujjuaq. Also, at the time of the last communication received from the pilot, the FSS specialist gave him the Kuujjuaq weather conditions. The pilot did not ask the FSS specialist to give him the regional forecasts, and the specialist did not transmit them to him.

1.7.2 1230 Area Forecast

According to the area forecast, FACN3 CWUL, issued by the Quebec weather centre at 1230, there would be broken layers of cloud from 4,000 feet above sea level (asl) to 14,000 feet asl covering the area. Towering cumulus (TCU) and isolated altocumulus castellanus up to 16,000 feet asl were forecast, giving showers reducing visibility to between four and six miles with lower ceilings between 1,500 and 2,500 feet asl.

At about 1900, or near the time of the occurrence, there would be a broken layer of cloud at between 2,000 to 3,000 feet asl and 18,000 feet asl covering the area. Frequent overlapping TCU up to 18,000 feet asl were forecast, giving showers reducing visibility to between two and six miles and lower ceilings, between 800 and 1,000 feet asl.

1.7.3 Analysis of Weather Conditions

An analysis of the weather conditions was done by Environment Canada's Atmospheric Environment Service. All the information available for 24 September 1994 at the time of the occurrence indicates that in the region between Kuujjuaq and Kangiqsualujjuaq, the probable weather conditions were marginal for VFR flight (MVFR). Specifically, the conditions were probably as follows:

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[4] Transportation Safety Board of Canada, Report No. 90-SP002, *Safety Study of VFR Flight into Adverse Weather Conditions* (Ottawa: Minister of Supply and Services Canada, 1990)

[5] Ibid., *Staff Report*, page 128.

- clouds giving a ceiling between 2,000 feet and 3,000 feet asl;
- visibility of three to four miles in rain and fog;
- scattered clouds (stratus fractus) based at 1,000 feet asl and the possibility of a ceiling at that level;
- surface winds from the south at nearly 10 knots;
- significant wind shear between the surface and 1,000 feet, causing moderate turbulence;
- freezing level at 9,000 feet; and
- no form of icing.

1.7.4 Observed Meteorological Conditions

At the camp, the cloud ceiling was estimated at 1,500 feet and visibility at two miles in fog.

Before taking off from the camp for the return flight to Kuujjuaq, the pilot told a witness that the in-bound flight had taken place in conditions of drizzle and fog similar to those at the camp. A number of persons who were at the fishing camp witnessed the take-off. They saw the aircraft flying off toward the west before disappearing in the fog, drizzle, and darkness. About five minutes later, heavy showers from the west fell on the camp.

Shortly after the expected arrival time of the helicopter, a twin-engined Piper PA28 Aztec flew to a point 30 miles east of Kuujjuaq, at the request of the FSS, in order to contact C-FPHI. The Aztec pilot reported encountering heavy showers in a very dark night.

According to the regular observations, VFR conditions prevailed at Kuujjuaq for the duration of the flight up to the time of the occurrence.

1.7.5 Weather Conditions and Sensory Illusions

When it is impossible to establish aircraft orientation by external reference to the ground or the horizon, a pilot must rely completely on aircraft flight instruments. Reliance on other than visual cues will quickly cause the pilot to lose his spatial orientation.

According to a study published by the National Transportation Safety Board (NTSB)[6], the predominant factor causing fatal accidents during MEDEVAC flights is the pilot's inadvertent continuation of VFR flight in weather conditions that require instrument flight (IMC); the majority of these accidents have occurred at night. The study also states that pilots inexperienced in instrument flight rarely succeed in overcoming spatial disorientation.

1.8 Aids to Navigation

It was established that the pilot was in the habit of navigating using only the GPS, and that there was no aeronautical chart on board the aircraft.

The Kuujjuaq airport was equipped with distance measuring equipment (DME), an instrument landing system (ILS), a very high frequency (VHF) omni-directional range (VOR), and a non-directional beacon (NDB).

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[6] National Transportation Safety Board. (1988). *Commercial Emergency Medical Service Helicopter Operations*. (NTSB/SS/88/01). Washington, DC. (P. 9).

The Kangiqsualujjuaq airport had an NDB.

The navigation systems on board the aircraft were capable of receiving the signals transmitted by the Kuujjuaq airport VOR.

1.9 Communications

The pilot was able to communicate with the FSS or with other aircraft using a high frequency (HF) radio and a VHF radio. HF transmissions, unlike VHF transmissions, are not limited to visual range. Unfortunately, the HF was subject to atmospheric interference during the flight. This made the HF transmissions practically inaudible, and the pilot had to use VHF to ask the crew of FAB 867 to relay his expected arrival time to the FSS. The pilot did not declare an emergency or indicate that he was having any problems.

The VHF air-ground communications systems functioned normally during the flight. The air-ground communications between the pilot and the FSS specialist were recorded on magnetic tape by Air Traffic Services (ATS).

During a helicopter flight following the accident, the TSB verified the VHF radio range over the accident site. Two-way communication between the aircraft and the Kuujjuaq FSS was established from 500 feet asl.

1.10 Aerodrome Information

1.10.1 Kuujjuaq

The airport is located just south of Kuujjuaq. Lighting systems were available for both runways. Because it is close to the town, the airport is easily located at night.

1.10.2 Kangiqsualujjuaq

The airport at Kangiqsualujjuaq is located on the river bank downstream of the fishing camp and about 15 miles to the north. Lighting systems were available for the runway.

1.11 Flight Recorders

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

1.12 Wreckage and Impact Information

1.12.1 General Information

The accident site was on a magnetic heading of 111 degrees, 38 miles from Kuujjuaq. The helicopter was banked to the right when it crashed in a peat bog, at a nose-down angle of about 55 degrees. Pieces of the wreckage were lying on either side of a line on a magnetic heading of 195 degrees, or nearly 90 degrees to the left of the planned flight route. The debris was scattered over an area of about 340 feet by 150 feet.

Although all the main components of the helicopter were found, some parts could not be located. Examination of the wreckage and the systems did not reveal any anomaly that could have hampered control of the aircraft before the collision with the ground.

1.12.2 Flight Instruments

Microscopic examination of the vertical speed indicator dial showed the distinct imprint of a line left by the needle at the maximum downward reading, indicating a rate of descent of more than 2,000 feet per minute.

Examination of the longitudinal and lateral inclination scales of the attitude indicator did not provide any indication as to the helicopter's attitude when it struck the ground for the first time. It was deduced that the attitude indicator was functioning at the time of impact, and, from that observation, that it was supplied with 28 volts DC.

The GPS was recovered; unfortunately, the memory block had become detached from the supply block, so no information could be obtained from it.

The filaments from the left and right rear navigation lights were intact. However, they had been stretched significantly, indicating that they were lighted or powered at the time of impact.

Examination of the face of the airspeed indicator and the turn-and-slip indicator did not yield any reliable information.

1.12.3 Flight Controls

The flight controls suffered major damage, and control continuity could not be confirmed. However, examination of all components recovered did not reveal any breakage or malfunction prior to impact. All breakages were attributed to overloads.

1.12.4 Engine

The engine (Turbomeca-Ariel) was examined at the Turbomeca plant in Texas, in the presence of a U.S. National Transportation Safety Board (NTSB) investigator. The engine was turning at the time of impact; however, from the examination, it could not be determined how much power it was developing.

1.13 Medical Information

1.13.1 The Pilot

There was no evidence that incapacitation or physiological factors affected the pilot's performance. His latest medical examination was in November 1993. His licence validation certificate was valid and did not bear any restriction.

According to his medical file, the pilot had been consulting a lung specialist and an ear-nose-and-throat specialist since November 1992. He suffered from asthma and allergies that required him to carry adrenalin with him. Although the pilot should have reported these ailments to the civil aviation medical examiner, the civil aviation medical examination reports do not mention them.

Section 6.5 of the *Aeronautics Act* requires a pilot to identify himself or herself as the holder of a pilot licence before being examined by a physician. Section 6.5 also requires the examining physician to

inform the Minister of Transport if the patient has a condition that is likely to constitute a hazard to aviation safety. The section further states that a pilot is deemed to have consented to have the physician inform the Minister of any finding concerning his condition that relates to aviation.

1.13.2 The Patient

The autopsy was not able to distinguish between the injuries suffered by the patient in the fishing accident and those caused by the crash. However, it was established that she had suffered serious injuries that required two intravenous drips before the flight. The patient was weak but calm when she was placed in the helicopter.

1.14 Fire

Inspection of the accident site and examination of the wreckage and the engine yielded no evidence that there had been a fire during the flight. The fuel tank was ejected upon impact. A number of small fires ignited after the impact but went out on their own.

1.15 Survival Aspects

The accident was not survivable because of the high impact forces.

1.15.1 Search and Rescue

The emergency locator transmitter, which was mounted in the nose of the helicopter, was destroyed on impact.

The aircraft was reported missing 25 minutes after its expected arrival time. The Canadian Forces were responsible for the search and rescue service. Five Canadian Forces aircraft and many civilian aircraft took part in the search. The helicopter was found five days after the accident, approximately five miles from its last known position.

1.16 Héli-Harricana Inc.

1.16.1 Organizational and Management Information

Héli Forex Inc., a company that operates under the names Héli Forex and Héli-Harricana, is an air carrier offering helicopter charter service to the public. The company's operations are administered from its main base at Val d'Or, which includes offices, maintenance facilities, and support personnel.

According to the company hierarchy, pilots reported to the chief pilot, who reported to the director of operations. The director of operations was responsible for flight safety. The responsibilities of base manager were not defined.

1.16.2 Héli-Harricana Procedures

Héli-Harricana was authorized to operate its aircraft by day in VFR conditions only.

The company had prepared an operations manual to help its operational personnel carry out their duties. The standards, practices, procedures, and specifications reflected the company's operating policies and were in compliance with government acts and regulations. All operational personnel were required to know and apply the procedures described in the operations manual. The operations manual

was in the aircraft at the time of the accident. The company had not established a specific procedure for MEDEVAC flights, and none was required.

The NTSB[7] analyzed the effect of a mission on a pilot's judgement and concluded that pilots are occasionally subject to strong pressure to complete a MEDEVAC flight and that the support provided by the operator plays a decisive role in safety:

> "The power of the mission itself to influence and perhaps override an EMS pilot's judgement is enhanced by the lack of a strong managerial structure to support the pilot in the working environment."

1.16.3 Pilot Responsibilities

Article 3.2.4, "PILOT-IN-COMMAND," of the company's operations manual stipulates that before take-off, the pilot must familiarize himself with the planned route and the weather forecasts for the flight.

Also, article 3.2.4.1 of the operations manual, "PILOT-IN-COMMAND In-Flight," states the following:

> In the course of the flight the pilot-in-command shall ensure that:
>
> a) the aircraft is operated in accordance with the Rules of the Air. When, however, an emergency arises, endangering the safety of the aircraft or persons, that necessitates action in contravention of regulations or procedures the pilot shall take such actions as he judges to be appropriate in the interest of safety. He shall notify the appropriate local authority of the deviation without delay; ...

1.17 Regulatory and Operational Framework for MEDEVAC Flights

1.17.1 Transport Canada (TC) and MEDEVAC Flights

TC does not recognize transfers of patients as specialized flights and has not drafted specific standards for MEDEVAC flights. The *Aeronautics Act* does not provide for any deviation from the weather minimums and VFR night flights for MEDEVAC flights.

1.17.2 Comparison Between the Management of MEDEVAC Flights in Quebec and in Ontario

Each province administers its MEDEVAC flight program according to its own standards and procedures.

1.17.2.1 MEDEVAC Flights in Quebec

Quebec operates aircraft dedicated to transporting patients from remote areas who need care that is available only in a specialized hospital. However, as in most provinces, there is no infrastructure for managing first response and on-scene assistance MEDEVAC flights. The Health ministry has neither operating policies nor standards for this type of flight. In general, first response and on-scene assistance MEDEVAC flights are made on an *ad hoc* basis according to the existing air regulations.

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[7] National Transportation Safety Board. (1988). *Commercial Emergency Medical Service Helicopter Operations.* (NTSB/SS/88/01). Washington, DC.

Typically, a person or agency that decides to carry out an emergency evacuation of a patient contacts the operator of its choice directly. The operational decision as to whether to undertake the flight is then up to the pilot.

The pilot is responsible for flying the aircraft in such a way as to ensure that passengers are carried in complete safety and in accordance with the existing regulations. However, in remote areas, where sick and seriously injured persons can be evacuated only by air, pilots are likely to be faced with serious moral dilemmas when they judge that a flight can be carried out only in contravention of the regulations.

1.17.2.2 MEDEVAC Flights in Ontario

Ontario has a first response and on-scene assistance MEDEVAC system administered by the Ministry of Health. In short, all requests for MEDEVAC flights are assessed and processed by the Medical Air Transport Centre, a flight regulation centre located in Toronto. Centre staff gather the information on the patient and make the necessary arrangements to have a suitable aircraft transfer the patient.

Specially equipped fixed-wing aircraft and helicopters dedicated exclusively to ambulance transport are based in five Ontario cities and operate 24 hours a day. These aircraft are under contract to the Ministry of Health. Also, a number of other aircraft are used on an *ad hoc* basis. The operators must comply with operating and safety standards stricter than those in the existing regulations and those used in the aviation industry. Twenty-three operators are approved for patient transport. In this way the Ministry of Health ensures that the aircraft are certified for this type of flight and that the flight crews are qualified to carry out the missions.

2.0 Analysis

2.1 Introduction

The investigation established that the pilot had considerable flying experience and was considered professional and competent by his peers. He showed a marked concern for flight safety by taking two courses on risk management not required by Transport Canada. The analysis, therefore, concentrates in part on the circumstances that led to the flight being undertaken and continued in conditions where safety was in doubt.

2.2 The Aircraft

Although the aircraft was equipped with the instruments necessary for instrument flight, flying the aircraft under instrument conditions would have been exceedingly difficult without a stability augmentation system.

Examination of the wreckage and a detailed study of the helicopter components did not reveal any indication that the helicopter had suffered a structural failure, problems with the flight controls, electrical problems, loss of engine power, or fire while in the air.

2.3 Flight Planning

Because no fixed-wing aircraft was able to go to the camp and make the return flight at night, it was assumed that the patient could be evacuated only by helicopter.

The pilot did not evaluate correctly either the total duration of the flight or the time at which night would fall, because at the time the dispatcher contacted him, it was already too late to go to the camp and return to Kuujjuaq before nightfall. Also, the pilot undertook the flight without obtaining the available information about the observed and forecast weather conditions along the route. The pilot's flight planning was deficient, possibly because he had little time available to prepare the helicopter in response to the emergency and to complete the flight.

The pilot and the dispatcher had discussed the possibility of evacuating the patient from the fishing camp by making a short flight to Kangiqsualujjuaq, after which the patient could have been transported by fixed-wing aircraft to Kuujjuaq during the night. However, the pilot agreed to make the flight, knowing that he would land at the camp in daylight and would then decide at that point whether to go to Kangiqsualujjuaq.

2.4 The Flight

The reason why, with night falling, the pilot took off from the camp toward Kuujjuaq, rather than toward Kangiqsualujjuaq, could not be determined. Shortly after his arrival at the camp, the pilot indicated that the patient would be evacuated to Kangiqsualujjuaq as he had planned. However, after discussion with the physician, the pilot confirmed that he would return to Kuujjuaq, even though he did not have the qualifications necessary for night flight and the helicopter was not certified for that purpose. This change of destination suggests that the patient's condition was critical and required

evacuation to Kuujjuaq without delay. It is likely that the patient's condition influenced the pilot in his decision and that he agreed to undertake the night flight to Kuujjuaq for humanitarian reasons.

Specific directives and procedures for carrying out MEDEVAC flights would have helped the pilot to plan the flight better and to make well-informed decisions. In general, hospitals and medical personnel are not concerned by aeronautical factors, but rather by the medical condition of their patients, particularly when the decision to evacuate them must be made. Many of them are unaware of the factors that can affect flight safety, such as air regulations, the weather, instrument flight, or night flight. Helicopters are considered merely vehicles for transporting the sick or injured. For their part, although pilots may have little medical knowledge, no pilot can remain insensitive to the condition of a patient requiring evacuation without delay, making it particularly difficult for a pilot to decide whether or not to undertake a flight when it is a MEDEVAC one.

In the absence of specific directives regarding MEDEVAC flights, the pilot had to make an operational decision on his own, at a time when his judgement may have been coloured by the pressure of the mission. Because of the apparent urgency of evacuating the patient to Kuujjuaq and the difficulty of communicating with Kuujjuaq by HF to obtain more information, the pilot probably judged it appropriate to make the night flight in violation of the regulations in effect.

2.5 Meteorological Conditions

The pilot undertook the flight to the fishing camp without finding out about the observed and forecast weather conditions along the route. The pilot stated that the trip to the camp had taken place in conditions of fog and drizzle similar to those prevailing at the camp when he arrived. The return flight was made over an uninhabited area, on a dark night, under an overcast sky and in marginal conditions. The fact that the pilot delayed the expected time of arrival in Kuujjuaq by ten minutes indicates that he had reduced the helicopter's speed. That speed reduction was probably a result of the adverse conditions encountered. In continuing his path to the west, the pilot was likely faced with reduced visibility in shower conditions similar to those observed by the pilot of the Aztec shortly after the crash. The pilot continued the night flight in adverse weather conditions which he was not able to recognize in time because of the low light level.

2.6 Impact with the Ground

The pilot was taking a great risk of losing sight of the ground in the existing environmental conditions. Because he was not IFR qualified and was not experienced in instrument flying, the pilot could not fly using only the flight instruments with which the helicopter was equipped; also, without a proper external visual reference, the pilot was subject to spatial disorientation. Given the flight profile and the helicopter's attitude at the moment of impact, the high horizontal and vertical speed, and the fact that no technical breakdown was found, it can be concluded that the pilot lost contact with the visual references necessary to fly the helicopter, and that he did not see the ground before the impact.

3.0 Conclusions

3.1 Findings

1. The pilot was licensed and qualified to carry out the flight in VFR conditions in accordance with existing regulations.

2. The pilot was not qualified for night flight.

3. The pilot was not trained, experienced, or qualified for instrument flight.

4. The aircraft was certified and equipped in accordance with existing regulations and approved procedures.

5. The on-board systems were examined to the extent possible, and all indications are that they were functioning normally.

6. The helicopter was not certified for IFR flight.

7. Flying the helicopter under instrument flight conditions would have been exceedingly difficult given that the helicopter had no stability augmentation system.

8. The pilot did not request a weather briefing before or during the flight.

9. The MEDEVAC flight took place on a dark night under an overcast sky in marginal conditions.

10. The pilot continued the flight in adverse weather conditions which he was likely not able to recognize because of the low light level.

11. The flight profile and the helicopter's attitude at the moment of impact, and the high horizontal and vertical speed, suggest that the pilot had lost his spatial orientation.

12. The atmospheric interference made HF radio communications practically inaudible.

13. The patient's condition was probably serious, requiring immediate evacuation.

14. The patient's condition likely influenced the pilot in his decision to undertake the night return flight to Kuujjuaq.

3.2 Causes

While on a night MEDEVAC flight, the pilot likely lost his spatial orientation when he continued the flight in adverse flight conditions which he was not able to recognize in time because of the low light level. Contributing factors to the accident were that the pilot was not qualified for night flight or for instrument flight, and that the patient's condition likely influenced the pilot's decision to undertake the night return flight to Kuujjuaq for humanitarian reasons.

4.0 Safety Action

4.1 Safety Concerns

4.1.1 System Failure

Accidents involving continued VFR-into-IMC account for a disproportionate number of fatalities each year. The causes and contributing factors to these accidents have recurring themes, which are also seen in this accident at Kuujjuaq. In the Board's opinion, these themes include inappropriate pilot qualifications or proficiency for the conditions encountered, and shortcomings in the permissible weather minima for VFR flight, in pilot training, and in pilot licence privileges. In some cases, current industry practices and limitations in aircraft equipment and weather briefing facilities exacerbated the circumstances leading up to the accidents.

This preventable accident at Kuujjuaq again underlines several safety deficiencies previously identified by the Transportation Safety Board (TSB) and its predecessor, the Canadian Aviation Safety Board (CASB); these deficiencies represent failures in the system, from pilots' decision making, through the adequacy of companies' operational control, through the provinces' lack of a system for retaining and controlling operators for MEDEVAC flights, through the overall effectiveness of regulatory efforts.

4.1.2 TSB Study of VFR-into-IMC Accidents

In 1990, the TSB reported on a safety study of 352 weather-related accidents that occurred between 1976 and 1985 and involved Canadian registered aircraft. (TSB Report No. 90-SP002).

The study noted that, whereas 12.7 per cent of all the Canadian accidents during the study period involved fatalities, fully 50.2 per cent of Canadian VFR-into-IMC accidents resulted in fatalities. Almost one-fifth of these accidents involved pilots with more than 3,000 hours total flying time. Whereas charter operations account for less than 19 per cent of all accidents, they comprised almost 27 per cent of the VFR-into-IMC accidents. The accident at Kuujjuaq (A94Q0182) was yet another fatal VFR-into-IMC accident involving a charter pilot with more than 8,000 hours flying experience.

The study made 26 safety recommendations aimed at reducing the frequency and severity of such accidents. In the Board's opinion, Transport Canada's (TC) responses to 12 of these recommendations remain unsatisfactory; the responses to another two are considered to be only satisfactory in part. Not all of these recommendations are pertinent to the accident flight; nevertheless, the lack of progress in redressing the underlying safety deficiencies is indicative of regulatory inertia.

Appendix A includes a summary and discussion of some of the study's recommendations which are directly pertinent to this accident at Kuujjuaq.

4.1.3 Controlled Flight into Terrain (CFIT)

Although the Kuujjuaq accident involved loss of control, given the ambient operating conditions, it could easily have been a CFIT accident. The Board is concerned about the frequency and severity of CFIT accidents involving small commercial operators.

Between 01 January 1984 and 31 December 1994, 70 commercially operated aircraft, not conducting low-level special operations, were flown into terrain, water, or obstacles while under control, with no awareness on the part of the crew of the impending impact. Of these 70 CFIT accidents, 35 claimed

106 lives and left 23 persons seriously injured. Two-thirds of these accidents involved aircraft being flown by a single pilot in the sparsely settled areas of Canada.

The crew were often attempting to see the ground in order to fly visually, although they were flying in cloud, in the dark, in whiteout, or in other conditions which did not permit visual flight. More than half of these CFIT accidents were conducted under VFR; however, the weather conditions were nearly always below those required by regulations. Over one-third of the CFIT accidents occurred at night (whereas only about one-tenth of accidents involving commercial aircraft in Canada occur at night).

In consequence of the foregoing, the TSB is currently completing a safety study into CFIT accidents. Undoubtedly, there will be significant linkages to those aspects of the VFR-into-IMC study which remain unattended.

4.1.4 MEDEVAC Accidents

Although this accident at Kuujjuaq was not a CFIT accident per se, it occurred under circumstances very similar to many CFIT accidents involving MEDEVAC flights. A disproportionate number of the CFIT accidents currently being studied occurred on MEDEVAC flights, most of them during dark nights. When CFIT MEDEVAC accidents have occurred, the circumstances were frequently such that the flight crew was attempting the flight with a sense of urgency; this urgency, which compelled the crew to bypass the usual safeguards to expedite the flight, may have been more perceived than real. Most CFIT and VFR-into-IMC MEDEVAC accidents occur in a self-dispatch environment, without the first level of planning and monitoring that an effective dispatcher affords.

Between 1976 and 1994, there were 38 occurrences involving aircraft engaged in air ambulance or medical evacuation operations. Fifteen of these accidents took place in Canada's designated North. Helicopters were involved in eight of the accidents. Twenty-one of the MEDEVAC accidents occurred during VFR flights, and 18 occurred during dark nights (i.e., notwithstanding reported flight visibility conditions, the absence of ambient lighting, either from surrounding built-up areas or from the moon, created extra problems for conducting flight by outside visual reference). Twelve of the 38 MEDEVAC accidents were CFIT accidents, 10 of which occurred at night.

The TSB's Confidential Aviation Safety Reporting Program has received 17 reports on MEDEVAC operations since 1987. Some of these reports made direct reference to pilots' perceived sense of urgency with respect to MEDEVAC operations. In situations where the conditions are known to be inadequate for the intended flight, crews frequently attempt the flight anyway, with the humanitarian objective to save lives. Confidential reporters also confirmed that the absence of any positive operational control over their flights had an impact, in that it led to a risk-taking attitude under the perceived pressure of the medical emergency. As the National Transportation Safety Board (NTSB) study cited earlier in this report suggests, a strong managerial structure is required to support pilot decision making in the working environment of MEDEVAC operations.

4.1.5 Location of ELT

Over the years, the TSB and the CASB frequently identified problems with respect to the serviceability and crashworthiness of emergency locator transmitters (ELTs). In view of the occurrence record, the Board is concerned that the standards governing where ELTs and their antennae are located on helicopters may not ensure an adequate level of crashworthiness to facilitate both rescue and investigative activities. In the Kuujjuaq accident, had any of the passengers survived the impact, it is unlikely that they would have survived the five-day wait for search and rescue personnel to find them--notwithstanding that they were only 38 miles from Kuujjuaq.

4.1.6 Medical Condition of Pilot

The medical condition of the accident pilot that required him to carry adrenalin is not mentioned in his civil aviation medical examination report, although the regulations require that pilots self-declare their status as pilots to examining physicians, and the condition should have been declared by the pilot during annual TC medical exams. The condition was serious enough to warrant the carrying of adrenalin, a medication with potent physiological effects and potentially dangerous side effects. Notwithstanding that there was no evidence found that incapacitation affected the pilot's performance, the regulatory and company safety systems failed to detect a significant medical condition, potentially threatening to safe passenger-carrying operations.

In 1985, the CASB investigated a fatal accident involving a self-medicating pilot who had a chronic asthmatic condition and who had not declared his condition to an aviation medical examiner, as required by regulation (CASB 85-H0005). The same pilot had been involved in an earlier accident for which there had been inadequate TC follow-up assessment of the pilot's competence and medical fitness to hold a licence. The CASB subsequently recommended that:

> The Department of Transport expand its program of information dissemination pertaining to the hazards of inappropriate use of medication while flying.
>
> (CASB 87-12, issued August 1987)

In their response, TC recognized that a hazardous potential exists for abuse through self-medication. As a consequence, they instituted several information programs using, as their forum, workshops and newsletters. However, the need for increased vigilance within the medical community, specifically by the physicians authorized to perform TC licensing medical examinations, was not addressed.

4.1.7 Use of Global Positioning System (GPS)

The introduction and widespread use of GPS has radically altered navigation in the remote regions of Canada. Not surprisingly, GPS is in wide use; however, standards for the certification of such equipment and training in its proper use have lagged behind the technology. The Board is concerned about the extent to which GPS has been used as an unauthorized navigation aid in many accidents that the TSB has investigated. In this accident, the pilot did not even carry an aeronautical chart. Following a fatal accident at Sandy Lake, Ontario, the Board recommended that:

> The Department of Transport initiate a national safety awareness program addressing the operating limitations and safe use of GPS in remote operations.
>
> (TSB A95-08, issued March 1995)

In response, TC is attempting to meet the intent of this recommendation through its promotional materials. However, the Board remains concerned that many pilots are developing unsafe operating practices, pressing on into adverse weather with unwarranted confidence in the device, without consideration of their own ability to navigate and control the aircraft, and maintain adequate terrain clearance without outside visual reference.

4.1.8 Regulatory Effectiveness

This accident underlines a range of shortcomings in the safety system with respect to such diverse areas as airworthiness considerations, medical considerations, pilot licensing, weather minima, use of GPS, operational control, risk management, and regulatory audit. The Board

notes that, in the recent past, TC has been highly focused on major organizational change, including significant downsizing, with the provision of some services being privatized or commercialized. It is understood that the new and revitalized TC will focus on improved regulation and safety. The Board is not making any recommendations as a consequence of this occurrence in the belief that TC's changing focus will provide it with the opportunity to address the recurring systemic problems evidenced by this occurrence.

This report concludes the Transportation Safety Board's investigation into this occurrence. Consequently, the Board, consisting of Chairperson John W. Stants, and members Zita Brunet and Maurice Harquail, authorized the release of this report on 07 February 1996.

Appendix A - Discussion of TSB Safety Study Recommendations on VFR-into-IMC Accidents

VFR Weather Minima

Seventy-four of the accidents studied (in TSB Report 90-SP002) involved pilots who lost control of their aircraft in reduced forward visibility; 80 per cent of these occurred in uncontrolled airspace where the visibility minimum was one mile for fixed-wing aircraft (1/2 mile for helicopter). Since these visibilities leave no margin for error, and permit pilots to fly in weather conditions in which there is inadequate outside reference to ensure consistent aircraft control, the Board recommended that:

> The Department of Transport establish VFR visibility minima which will permit pilots to retain control of their aircraft by outside reference.
>
> (TSB A90-65, issued December 1990)

Although TC has proposed an amendment to the Canadian Aviation Regulations (CARs) to introduce a two-nautical-mile flight visibility requirement where aircraft are flying in uncontrolled airspace less than 1,000 feet above ground or water, proposed TC standards would allow lesser limits than the CARs. It should be noted that American weather minima reduce the risk to fare-paying passengers in commercially operated aircraft by being more restrictive for commercial VFR operations than for private or recreational operations. Although the accident pilot (A94Q0182) did not avail himself of any weather briefing, more restrictive VFR minima for commercial operators might have affected his overall decision making.

Night Visual Flight

Approximately 10 per cent of all Canadian accidents occur during the hours of darkness, which parallels estimates of the general level of night flying activity. However, VFR-into-IMC accidents occurring during the hours of darkness accounted for approximately 30 per cent of the total study accidents. The consequences of flying in reduced visibilities are exacerbated when operating at night, in light conditions which do not permit sufficient warning for the pilot to see and avoid worsening weather conditions. The high proportion of fatal night accidents attributable to adverse weather is in part the consequence of pilots initiating flight in weather conditions which are legally acceptable, but which deteriorate. The night-flying pilot's first indication of deteriorating weather can be the inadvertent entry into IMC, as was likely the case in this accident. The study recommended that:

> The Department of Transport increase VFR weather minima for night flight so as to reduce the risk of inadvertent flight into poor en route weather conditions.
>
> (TSB A90-71, issued December 1990)

This recommendation has been satisfactorily addressed in that minimum flight visibility for night VFR flight will be raised to three nautical miles in the CARs. However, this accident raises questions as to how well the new minima will be put into practice by the aviation community.

Night Weather Briefing

In light conditions in which hazardous weather conditions cannot be detected until they have been encountered, it is essential that pilots have appropriate information before initiating flight. Seventeen of the study's accidents that occurred in other-than-daylight conditions involved pilots who did not use available weather briefing facilities. There are no regulations specifically requiring a weather briefing before VFR flight; yet the probability of inadvertent entry into IMC at night could be reduced if pilots

had appropriate information upon which to base their decision to initiate or defer a flight. Therefore, the Board recommended that:

> The Department of Transport require that, prior to initiating night flight under VFR from locations for which weather briefing facilities exist, pilots engaged in commercial passenger-carrying operations obtain a weather briefing.
>
> (TSB A90-73, issued December 1990)

The Board understands that there are now provisions in the proposed new CARs to require mandatory weather briefings for all flights from locations at which briefing facilities exist. However, the accident pilot chose not to obtain a weather briefing from the Kuujjuaq FSS before departure.

Licence Privileges

Eighty per cent of the VFR-into-IMC accidents and 89 per cent of the fatalities occurred during the en route phase of flight. Nearly a quarter of the other-than-daylight accidents occurred after the pilots lost control of the aircraft, as in this accident. In consideration of the high proportion of night VFR-into-IMC accidents, most of which occur en route and many of which result from the pilot having inadvertently encountered IMC, only suitably qualified pilots, flying aircraft certified for IFR flight, should be permitted to conduct cross-country flights at night under VFR. Therefore the Board recommended that:

> The Department of Transport develop a licence endorsement which permits VFR cross-country flight at night only in aircraft equipped to maintain control of the aircraft by reference to flight instruments.
>
> (TSB A90-78, issued December 1990)

In a subsequent letter to TC, the TSB clarified the need for both skills and equipment to cope with inadvertent entry into IMC. The Board understands that no further action has been taken with respect to this recommendation. The Board wonders how year-round commercial operations reliant on day-VFR pilots can be safe in Canada's North where the hours of darkness are so long. This accident pilot did not have a night endorsement, but had operated for a number of years in the sub-Arctic coastal zone of northern Quebec.

Helicopter Commercial Pilot Licence

Thirty-three of the VFR-into-IMC accidents studied involved helicopters; only one of the helicopter pilots had an instrument rating. Since July 1987, a candidate for a Commercial Pilot Licence for helicopters has had to obtain 20 hours of instrument flight time (combined actual and simulated). Before this, no instrument training was required; the pilot of this accident aircraft had not received such instrument training. There is no requirement for commercial helicopter pilots to undergo refresher training in basic instrument flying as a condition of licence-revalidation. In order to improve the skills necessary for coping with the major cause of VFR helicopter accidents in adverse weather, the Board recommended that:

> The Department of Transport require verification of proficiency in basic instrument flying skills for commercially employed helicopter pilots during annual pilot proficiency flight checks.
>
> (TSB A90-81, issued December 1990)

TC considered this recommendation to be financially and physically impractical. The Board understands that the new CARs will now permit some companies to fly in visibilities as low as one-half mile in uncontrolled airspace if certain conditions are met; however, pilots still will not be required to

demonstrate basic proficiency in flying with reference to instruments. Thus, commercial pilots with little or no instrument capability, such as the accident pilot, will be permitted to continue operating in regions where weather and light conditions are most conducive to inadvertent entry into IMC.

Risk Management in Commercial Operations

Approximately 35 per cent of the accidents occurred to aircraft engaged in commercial operations, frequently characterized by inappropriate operational decisions. The study observed that, until there is a major evaluation of the conduct of high risk operations in a demanding and unforgiving physical environment, the factors which impair decision making will remain unattended, and thus the management of risk in this demanding environment will be less than optimal. Although the Board made no recommendation in this respect, it did state that, without a reassessment of the methods by which many small, commercial operations are conducted, it feared the continuation of a high fatality rate associated with VFR-into-IMC commercial accidents. This accident at Kuujjuaq underlines the Board's earlier concern in that MEDEVAC flights may be conducted on an *ad hoc* basis without operators having met any particular standards for conducting such flights in the harsh physical environment of the Arctic.

Regulatory Standards for Commercial Operations

In light of the accident record of small commercial operations, and considering that there is, in general, a lower voluntary "margin of safety" built into these operations, the Board believed that the regulations governing these operations might require revision to safeguard the interests of the fare-paying public. While examining commercial VFR-into-IMC accidents, the Board found that a number of major users of Canadian aviation charter services stipulated additional safety criteria when they contracted air charter services. Major clients of Canadian charter services were demanding a higher standard of safety than provided by the regulations existing at that time, but a standard which industry practices could provide. The Board suggested that TC officials might wish to evaluate the existing practices of major clients of air charter systems to ascertain the most effective means by which the number and seriousness of VFR-into-IMC accidents could be reduced. The Board notes with concern that some provinces seem to have an *ad hoc* approach to the operational control of MEDEVAC flights. Basically, the first available charter flight is retained to conduct the MEDEVAC, often at the discretion of the attending physician. No specific measures are established to screen prospective companies, to define their minimum equipment and pilot training requirements, to govern the operational control of MEDEVAC flights, etc.

TC Regulatory Audit and Certification

Technical piloting skills were seldom found wanting in the accidents examined in the study, suggesting that the present method of evaluating pilots' skills does not address the root causes of most commercial VFR-into-IMC accidents. The study indicated that, without some means of evaluating pilots' decision-making skills, professional inadequacies will go undetected until after an accident has occurred. Therefore, the Board recommended that:

> The Department of Transport devise and implement a means of regularly evaluating the practical decision-making skills of commercially employed pilots engaged in small air carrier operations.
>
> (TSB A90-86, issued December 1990)

In response to this recommendation, TC expressed the view that the current system adequately evaluates pilot decision-making skills. Nevertheless, subsequent to a 1993 accident, the Board again recommended that:

> The Department of Transport establish procedures for evaluating crew resource management (CRM) and pilot decision-making (PDM) skills on a recurrent basis for all aircrew involved in commercial aviation.
>
> (TSB A95-12, issued April 1995)

TC's response indicated that CRM and PDM would be mandated only for the operators required to adhere to the Airline Operations regulations, i.e., only the large air carriers coming under CAR 705. Once again, the Board finds that the TC response will not adequately address the need to revalidate the decision-making skills of all pilots on a recurrent basis in the operating milieu where the licence holder will be exercising his or her privileges. The accident pilot had taken discretionary training in pilot decision making. However, there is no evidence that his decision-making skills in a MEDEVAC operating environment had been developed and evaluated. This is not surprising, given the current operating environment.

Appendix B - List of Supporting Reports

The following TSB Engineering Branch Report was completed:

LP 160/94 - Flight Instruments.

This report is available upon request from the Transportation Safety Board of Canada.

Appendix C - Glossary

asl	above sea level
ATS	air traffic services
CARs	Canadian Aviation Regulations
CASB	Canadian Aviation Safety Board
CFIT	controlled flight into terrain
CRM	crew resource management
CVR	cockpit voice recorder
DME	distance measuring equipment
EDT	eastern daylight saving time
ELT	emergency locator transmitter
FDR	flight data recorder
FSS	Flight Service Station
GPS	global positioning system
HF	high frequency
hr	hour(s)
IFR	instrument flight rules
ILS	instrument landing system
IMC	instrument meteorological conditions
lb	pound(s)
MEDEVAC	medical evacuation
miles	statute miles
MVFR	marginal visual flight rules conditions
NDB	non-directional beacon
nm	nautical miles
NTSB	National Transportation Safety Board (U.S.)
PDM	pilot decision making
PDP	Pilot Decision-Making Training Program
PPC	pilot proficiency check
TC	Transport Canada
TCU	towering cumulus
TSB	Transportation Safety Board of Canada
UTC	Coordinated Universal Time
VFR	visual flight rules
VHF	very high frequency
VOR	VHF omni-directional range

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