AVIATION OCCURRENCE REPORT

FLIGHT INTO TERRAIN

WESTLAND HELICOPTERS INC.
BELL 206 BIII JETRANGER C-GRAH
HOUSTON, BRITISH COLUMBIA 2.5 mi N
29 JANUARY 1994

REPORT NUMBER A94H0001

Transportation Safety Board of Canada
Bureau de la sécurité des transports du Canada

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Synopsis

The helicopter, a Bell 206 BIII, with the pilot and four passengers on board, was on a charter flight from Houston, British Columbia, to a ski cabin on Mount Morice, 10 miles to the south of Houston. The helicopter crashed approximately 2.5 miles to the north of its departure point. The helicopter was destroyed, and the pilot and passengers sustained fatal injuries.

The Board determined that the pilot, while attempting to climb through a fog layer by using rising terrain as a visual reference, most likely lost the visual cues required for flight in visual meteorological conditions (VMC). The helicopter struck a ridge, probably while the pilot attempted to regain his visual reference with the ground.

The pilot's decision to use the rising terrain as a visual reference under the existing visibility conditions was a contributing factor to this accident.

Ce rapport est également disponible en français.

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1.0 Factual Information

1.1 History of the Flight

1.1.1 The Occurrence Flight

At approximately 1200 Pacific standard time (PST)[1], a Westland Helicopters Inc. Bell 206 BIII helicopter (C-GRAH) was flown from its base in Houston,
British Columbia. The aircraft was on a charter flight to a ski cabin on Mount Morice, approximately 10 statute miles to the south[2] of Houston. The helicopter carried the pilot, four passengers, and approximately 100 pounds of baggage. The purpose of the flight was to transport the four passengers and their equipment to begin a cross-country skiing excursion in the Mount Morice area.

In order to climb above the fog layer in the Houston area, the pilot intended to proceed to the northeast of Houston using the rising terrain of
Mount Harry Davis as a visual reference. Once above the fog layer, the intent was to proceed to Mount Morice by following mountain peaks and ridges (refer to
Figure 1).

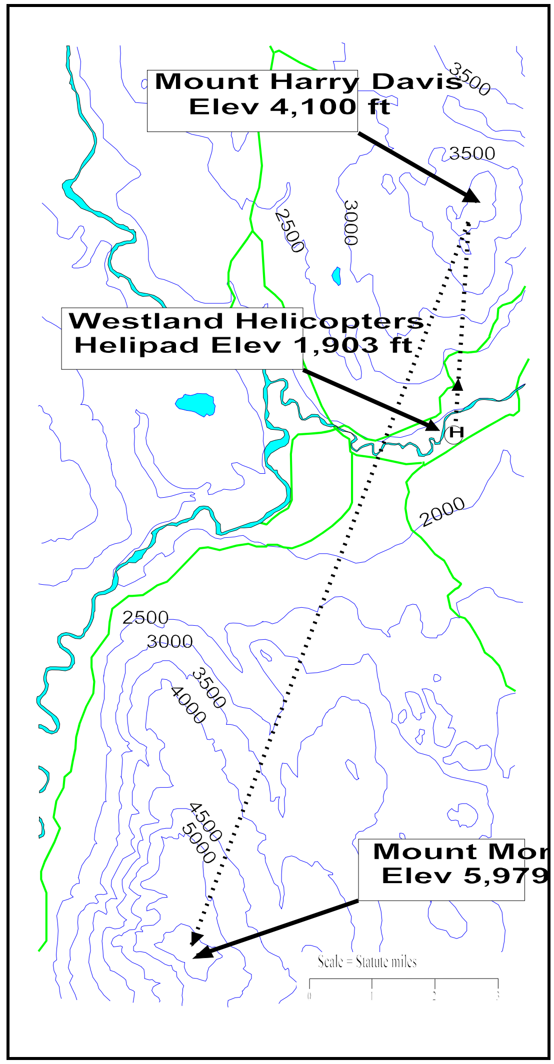


Figure 1
Area of Intended Flight

The flight was observed departing Houston at a low altitude and on a northeasterly track towards the rising terrain of Mount Harry Davis. The helicopter was heard in the Mount Harry Davis area flying in a northeasterly direction then in a westerly direction when the sound abruptly stopped. A few seconds thereafter, some witnesses stated that they heard the muffled noise of an impact.

The helicopter collided with the terrain at latitude 54°24'N and longitude 126°40'W, at approximately 1215 PST, at an elevation of 2,369 feet above sea level (asl)[3] (refer to Appendix A).

1 All times are PST (Coordinated Universal Time (UTC) minus 8 hours) unless otherwise stated.

2 All compass directions are relative to true north. Magnetic variation is 24° East.

1.1.2 Additional Operational Information

The flight was originally scheduled to depart at 0830 that morning and was to consist of two back-to-back shuttles to the Mount Morice area to transport the members of two families. Both families were to remain overnight in the Mount Morice area and ski to their vehicles which had been prepositioned at the base of the mountain.

On the morning of the accident, the pilot was informed that the members of one family were unable to depart until 1630. In addition, he was informed that the members of the other family would also be delayed and would be unable to make the 0830 departure. This change of plans eventually resulted in the delay of the original 0830 flight to a 1200 departure, and a second flight scheduled for 1630. There was no evidence that the pilot was under pressure from the customers to complete the revenue flight.

The pilot had previously made arrangements with some friends to fly to a fishing location on the completion of his early morning flight. About 1000 that morning, when he realized that his charter flight would be delayed, the pilot invited his friends to wait at his heliport while he completed the charter, which he estimated would take about 40 minutes. His intention was to continue with their original plan to fly the non-revenue fishing trip between the two charter flights.

3 See Glossary for all abbreviations and acronyms.

1.2 Injuries to Persons

	Crew	Passengers	Others	Total
Fatal	1	4	-	5
Serious	-	-	-	-
Minor/None	-	-	-	
Total	1	4	-	5

1.3 Damage to Aircraft

The aircraft was destroyed by the impact.

1.4 Other Damage

There was no other damage.

1.5 Personnel Information

1.5.1 General

	Pilot-in-Command
Age	39
Pilot Licence	Commercial
Medical Expiry Date	1 May 94
Total Flying Hours	2,993
Hours on Type	1,899
Hours Last 90 Days	58
Hours on Type Last 90 Days	58
Hours on Duty Prior to Occurrence	3
Hours off Duty Prior to Work Period	16

1.5.2 Pilot's History

The pilot commenced his flying career in September 1977 and obtained a commercial helicopter licence in April 1978.

In the fall of 1985, he underwent fixed-wing flying training in Moncton, New Brunswick. Included in this training was 19.2 hours of instruction on instrument flying techniques. This training did not entail any training in actual instrument meteorological conditions (IMC) and was the only instrument flying training known to have been received by the pilot.

The pilot had flown a variety of helicopter types and was experienced in mountain-flying operations. The majority of his flying experience was on the Bell 206 helicopter in various types of helicopter operations.

Based on numerous anecdotal weather-related entries in his pilot's log-book, it is known that the pilot had considerable experience operating the helicopter under visual flight rules (VFR) and in conditions of reduced visibility. There was no evidence found, however, that the pilot habitually flew in visibilities lower than permitted in existing regulations.

The pilot joined Westland Helicopters on 30 May 1993 as the base manager in Houston, British Columbia, and had flown out of that base on a regular basis since joining the company.

At the time of the accident, the pilot held a valid commercial helicopter licence and held a Category 1 medical with no restrictions. The pilot was not endorsed for flight in IMC.

1.6 *Aircraft Information*

1.6.1 *General*

Manufacturer	Bell Helicopter Textron
Type	206 BIII
Year of Manufacture	1981
Serial Number	3304
Certificate of Airworthiness (Flight Permit)	Valid
Total Airframe Time	6,068.1 hours
Engine Type (number of)	Allison 250-C20B (1)
Propeller/Rotor Type (number of)	Two-bladed/semi-rigid (1)
Maximum Allowable Take-off Weight	3,200 pounds
Recommended Fuel Type(s)	Jet B
Fuel Type Used	Jet B

1.6.2 *Helicopter Certification*

The helicopter was certified, equipped, and maintained in accordance with existing regulations and approved procedures.

The helicopter was not equipped or certified for flight in instrument meteorological conditions.

1.6.3 *Weight of the Helicopter at the Time of Impact*

According to the Bell 206 BIII flight manual, the maximum allowable helicopter weight for the flight was 3,200 pounds.

The helicopter was refuelled by the pilot on the morning of the flight but no records were found regarding the amount of fuel put into the helicopter. A review of the helicopter's journey log-book revealed that the pilot commonly put on only 500 pounds of fuel prior to commencing the day's flying activity.

The helicopter was equipped with a long range fuel extender which would have allowed for a maximum fuel capacity of 91 U.S. gallons. At 6.78 pounds per gallon, the maximum fuel weight which could have been on board was 616.98 pounds. The fuel consumption rate for the Bell 206 BIII helicopter is approximately 23 gallons (156 pounds) per hour. Allowing 45 minutes for the pilot's start-up and flight earlier that morning for a weather check, and assuming another 15 minutes for the accident flight, the helicopter would have burned a total of approximately 156 pounds of fuel prior to the occurrence.

Given the weight of the occupants and their baggage, and assuming that the pilot had refuelled the helicopter to its maximum capacity earlier that morning, the helicopter would have been at its maximum all-up weight (AUW) at the time of the occurrence.

In light of the pilot's prior refuelling habits, however, it was considered more likely that the pilot would have refuelled the helicopter to 500 pounds fuel capacity prior to the flight. In that case, at the time of the occurrence, the helicopter would have been approximately 150 pounds below its maximum AUW.

1.6.4 *Bell 206 Performance at Maximum AUW*

The accident site was at an altitude of 2,369 feet asl. The temperature at that altitude at the time of the occurrence was determined to be approximately 0° Celsius (C).

According to the helicopter manufacturer's performance charts, at the weights previously mentioned and at an outside air temperature of 0°C, the helicopter was capable of hovering out of ground effect up to an altitude of approximately 6,000 feet asl.

1.7 Meteorological Information

1.7.1 General

There were no Atmospheric Environment Services (AES) aviation forecasts or actual weather observations for Houston, British Columbia. The nearest aerodrome for which an aviation forecast and actual weather observations were issued was Smithers, British Columbia, 31 statute miles to the northwest of Houston.

1.7.2 Weather Conditions Known to the Pilot

At 0815 on the morning of the accident, the pilot called the Flight Service Station (FSS) at Smithers to inquire about the weather conditions. The Smithers FSS specialist informed the pilot that the weather at Smithers was an indefinite 400-foot ceiling and the visibility was 5/8 of a mile in fog. In addition, the specialist informed the pilot that, due to the weather, there had been no aircraft movements into or out of Smithers and there were no reports on the thickness of the fog.

The pilot informed the FSS specialist that the estimated visibility in Houston was 3/4 of a mile in fog.

Later that morning, at 0915, the pilot again called the FSS at Smithers and reported that he had just completed a flight to check the weather conditions in the Houston area. He reported that the surface visibility at Houston was approximately two miles in fog and that the ceiling was approximately 300 feet obscured.

He further stated that, during his flight, he was able to climb above the fog layer by flying up the rising terrain of Mount Harry Davis and using the trees as visual reference. While in the climb, he stated that he was able to see a distance of "about four or five tree-top lengths" (assumed to mean he could see four or five tree-tops ahead of him while flying) and that he was clear of the fog at 3,800 feet asl. He characterized these conditions as "helicopter VFR." Conditions above the fog were described as clear with only high scattered cloud.

1.7.3 Aftercast by Atmospheric Environment Services

A post-accident weather analysis prepared by AES determined that, on the day of the occurrence, a 1048 millibar arctic high pressure area centred over southeastern Yukon was generating a light northeasterly low level flow over central British Columbia. The air mass was stable and fairly moist in the lowest levels, but was dry aloft. Satellite imagery taken 1 1/2 hours after the accident revealed that the valley containing Houston was shrouded in fog and stratus. This stratus layer produced local ceilings of 300 to 800 feet and was topped at 3,500 feet asl. Skies were clear above this stratus layer.

Fog reduced the visibility to less than 1/2 mile in some areas. The temperature in the stratus layer was near but below the freezing mark and light rime icing would occur in the cloud.

Although there was a risk of freezing drizzle forecast for Smithers until 1200 PST and very light freezing drizzle was reported overnight in Smithers, it ended six hours prior to the accident and appeared to be very localized. The surface temperature and dew point at Smithers at the time of the occurrence were 0°C.

The low-level winds were generally from the northeast at less than 10 knots, and any turbulence would have been light.

1.7.4 Additional Weather Information

Approximately 1/2 hour after the accident, a helicopter departed its Houston base to search for the missing aircraft. The pilot reported that, because of reduced visibility in thick fog, he had to hover taxi over the trees up the side of Mount Harry Davis. He reported that the visibility was 1/4 of a mile or less, and that the fog was about 1,500 feet thick. In addition, he reported having encountered a trace of airframe icing while in fog, but said that no ice had accumulated on his windscreen.

1.8 Communications

There was no communication by the pilot with Air Traffic Services (ATS) nor was any required.

Prior to departure, the pilot had left a hand-held radio with his friends who would be waiting for his return. The radio was tuned to 159.72 megahertz (MHz), a frequency commonly used by the local forestry industry. The pilot had successfully conducted a radio check with his friends on this frequency prior to take-off. No further transmissions by the pilot were heard on this frequency.

1.9 Flight Recorders

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

1.10 Witness Observations

Friends of the pilot observed the helicopter depart to the northeast towards Mount Harry Davis until the helicopter was lost from view due to the fog. The elevation of the departure point was 1,903 feet asl.

A witness, approximately 1/2 mile to the northeast of the helicopter's departure point, heard the helicopter proceeding overhead to the northeast. He had listened to the helicopter manoeuvring for what appeared to be approximately 30 seconds when the noise suddenly stopped. Shortly thereafter, he heard a muffled impact sound.

Another witness, in her home approximately two miles to the northeast of the helicopter's departure point, heard the helicopter approaching from the southwest at low level. This witness was at the 2,500-foot level of Mount Harry Davis. She heard the helicopter proceeding northeastward up Mount Harry Davis then returning directly towards her home from the east. It was her impression that the helicopter was descending along the mountain directly towards her. The helicopter's proximity and low altitude caused her some concern until she heard the helicopter turn to a westerly direction and away from her house. At this point the helicopter was flying towards a small valley. The witness stated that the visibility in that direction from her vantage point was less than 300 feet. The witness heard the helicopter proceeding to the west until the sound abruptly stopped. Approximately three seconds later, the witness heard a muffled popping sound.

Another witness, approximately 1/2 mile to the west of the preceding witness and at an elevation of approximately 2,400 feet asl, heard the helicopter overhead proceeding to the west. This witness estimated the visibility at ground level as being 150 feet in fog.

All ear witnesses reported that, although they could clearly hear the helicopter, they could not see it because of the fog.

1.11 Search and Rescue Efforts

The emergency locator transmitter (ELT) was destroyed in the crash.

At approximately 1220, a witness who believed he had heard the sound of a helicopter accident passed this information to the individuals who were waiting at the hangar for the pilot's return. Attempts to contact the helicopter using the hand-held radio were unsuccessful.

At 1245, a local helicopter departed Houston to search for the missing helicopter. The search helicopter followed the intended route of the accident helicopter up Mount Harry Davis and, once on top of cloud at an altitude of approximately 4,000 feet asl, proceeded to the ski cabin on Mount Morice. No trace of the helicopter was found. Poor visibilities due to cloud and fog precluded searching in the Houston area below an altitude of approximately 4,000 feet asl. At approximately 1405, the search helicopter returned to its hangar to await an improvement in the weather.

Following this flight, the helicopter crew informed the local RCMP detachment and the Rescue Coordination Centre (RCC) in Victoria, British Columbia, of the missing helicopter. The RCMP alerted the Houston Provincial Emergency Program (PEP) ground search team, who began preparations for a ground search.
RCC Victoria began preparations to launch two military search aircraft from Comox, British Columbia. As local concern for the missing helicopter mounted, various individuals, including members of the local RCMP detachment, conducted a ground search using vehicles along local logging roads with no success.

At approximately 1515, after an improvement in the weather conditions, the local search helicopter departed on its second attempt to find the missing helicopter. It located the accident site at approximately 1530.

1.12 *Wreckage and Impact Information*

1.12.1 General

The helicopter had struck the ground along a ridge line which had an upslope of 6.5 degrees. The flight path angle prior to impact was determined to be 12 degrees down relative to the horizon. The wreckage trail was oriented on a track of 181° true and was 443 feet long and
190 feet wide.

At impact, the helicopter was yawed 17 degrees to the left, banked
9 degrees to the left and pitched 2 degrees nose down. Based on the wreckage scatter, its airspeed was conservatively estimated to be 100 mph and its rate of descent was determined to be in excess of 1,000 feet per minute (fpm).

Although all major components of the helicopter were recovered, deep snow prevented the locating of some of the smaller pieces of the wreckage. All the wreckage that was found was removed from the accident site for further examination.

The four sets of cross-country skis and poles which had been fastened to the skid gear of the helicopter were recovered at the site.

1.12.2 Instrument and Annunciator Panels

The instrument panel and the annunciator panel were sent to the TSB Engineering Branch Laboratory for examination
(LP 35/94). The instrument dial faces and internal drive assemblies were examined but provided little useful information. None of the light segments recovered from the annunciator panel exhibited evidence of being illuminated at impact.

1.12.3 Flight Control System

Most of the sections of the flight controls were recovered, with the exception of some fragments of casting and tubing in the cyclic control installation. All fractures were examined and, although severe impact damage was evident throughout, there was no evidence found of pre-impact failure.

1.12.4 Power Plant

The engine (Allison 250-C20B,
S/N CAE-833728) was examined at a Transport Canada (TC) certified engine overhaul facility by TSB staff.

The compressor had foreign object damage (FOD) to the first-stage through to the third-stage blades. There was considerable machining of the abradable material of the axial compressor housing. The impeller had machined into the aluminum case. The turbine section had aluminum particles fused to the blades and shrouds. There was some rub evidence on the fourth turbine wheel.

The above evidence indicates that the engine was operating and capable of producing power at impact.

1.12.5 *Transmission*

The transmission was being operated on a TC-approved time extension to 1,600 hours from the normal 1,500 hours; it had 1,584 hours at the time of the occurrence.

When examined, the input and output shafts turned normally, and all internal gears and bearings were in excellent condition and displayed no signs of wear or lack of lubrication. There was no evidence of an unbalanced condition on the transmission mounting points.

1.12.6 *Tail Rotor Gearbox*

The tail rotor input and output shafts, when examined, turned freely. The input and output splines were undamaged. There was some evidence of wear on the gears and bearings, but this wear was determined to be within serviceable limits.

1.12.7 *Hydraulic Servo Actuators*

The three hydraulic servo actuators were examined at a TC-certified overhaul facility. Both cyclic servo actuators were unremarkable; however, 18 fragments of ferrous material were found in the collective servo actuator. These fragments and the collective servo actuator were further examined at the TSB Engineering Branch Laboratory.

This component had been manufactured in 1979 and, at the time of the occurrence, had accumulated a total of 6,000 hours in service. It was concluded that the particles found in the servo actuator were likely machine turnings from some previous manufacturing process. They had likely been carried over within the interior passageways of the rod assembly, only to be released some time later in the operating life of the servo. The possibility that the fragments had somehow interfered with the operation of the collective control was considered.

The component had been installed in the accident aircraft since 1989 and there were no entries in the aircraft technical logs indicating any prior collective control difficulty.

The examination found evidence that at least three particles had been in contact with the servo spool valve during service (LP 80/94). Tests and analysis concluded that, given the physical characteristics of the contaminant particles found and the design and construction of the servo actuator and the collective control system, it is most probable that any interference with spool valve movement that might occur could be overcome by a collective control stick input force well within the capability of the pilot.

1.13 *Medical Information*

There was no evidence that incapacitation or physiological factors affected the pilot's performance.

1.14 *Fire*

There was no post-impact fire.

1.15 *Survival Aspects*

It was determined that all the occupants were wearing their seat-belts prior to impact. The seat-belts had all failed at their attachment points.

The accident was considered to be non-survivable due to the magnitude of the deceleration forces.

1.16 *Other Operational Factors*

1.16.1 Visual Flight Rules

The flight was to be conducted in uncontrolled airspace and in accordance with the weather minima for visual flight rules (VFR). These minima are detailed in Air Navigation Order (ANO) Series V, No. 3.

This ANO specifies that, in uncontrolled airspace, a helicopter may be operated below 700 feet vertically from ground or water provided that the flight visibility is not less than 1/2 mile. In addition, the ANO specifies that, when the helicopter is operated in reduced visibilities, it must be operated at such a reduced airspeed as will give the pilot-in-command adequate opportunity to see other air traffic or obstructions in time to avoid a collision.

According to TC Regulatory Compliance records, there has been no enforcement action taken by TC Pacific Region against any pilot for violations of this ANO during the past ten years.

Regulations provide for flights in lower visibilities only under specific circumstances, including flights necessary for the saving of human lives, such as the previously mentioned flight by the search helicopter.

1.16.2 Cloud Breaking Procedure Using Rising Terrain

Information gathered during the course of the investigation revealed that the technique used by the occurrence pilot to climb above a cloud or low fog layer is widely known in the Canadian commercial helicopter industry.

The procedure essentially requires that the pilot maintain visual contact with the rising terrain while flying at a reduced airspeed. This airspeed, depending on the terrain and/or weather conditions, may be as slow as a walking pace. The manoeuvre often requires that the helicopter be operated within the helicopter's critical height/velocity envelope until the helicopter is above the cloud or fog layer.

While performing this procedure, it is essential that the pilot not lose his visual reference with the ground and that the manoeuvre not exceed the performance limitations of the helicopter.

It is known that the occurrence pilot had used this technique the day before, had used it that morning to perform his weather check, and intended to use it again later that day on a non-revenue flight planned for after the accident flight. Company management stated that they were not aware that the pilot used this procedure and that "pressing the weather" was actively discouraged. When queried, various other experienced helicopter pilots stated that they were aware of the cloud-breaking procedure used by the occurrence pilot. The actual frequency of use of this practice by the occurrence pilot and by the helicopter pilot community at large could not be determined.

1.16.3 Translational Speed

The use of the above-mentioned technique as a fog- or cloud-breaking procedure often requires that the helicopter be flown at speeds below translational speed (approximately 10 to 15 knots).

When the helicopter is operated below this speed, in a hover for example, the helicopter requires considerably more power than it does in cruising flight. While in a hover, much of the rotor's energy is used to climb through an already moving column of air dispelled downward by the rotor. In forward flight, the air ahead of the rotor is not disturbed into previous motion and, as a result, the rotor reacts on more stable air, and the rotor's energy is used more efficiently and provides more lift.

1.16.4 Whiteout Considerations

The TC *Aeronautical Information Publication* (AIP) describes whiteout as an atmospheric optical phenomenon in which the observer appears to be engulfed in a uniformly white glow. Neither shadows, horizon, nor clouds are discernible; sense of depth and orientation is lost; only very dark, nearby objects can be seen. Whiteout occurs over an unbroken snow cover and beneath a uniformly overcast sky. Fog, falling snow, and blowing snow may also exacerbate and/or cause whiteout conditions. The AIP recommends that pilots avoid such conditions, unless they have suitable aircraft instruments and they are sufficiently experienced.

Interviews were conducted with a number of individuals who were either involved with the search efforts, witnessed the aircraft depart, or had heard the helicopter while in flight. All reported that the visibility was reduced in fog to distances of a few hundred feet. Those involved in the ground search efforts reported that local area secondary roads were snow covered and offered little contrast with the surrounding terrain, and that trees in the area of Mount Harry Davis were covered with snow and hoar frost. A number of the interviewees described the circumstances as conducive to whiteout conditions.

1.16.5 Spatial Disorientation

Spatial disorientation is a pilot's inability to sense correctly the position, motion, or attitude of his aircraft or himself with respect to a point in space, usually the earth's surface.

With good external visual references, maintaining orientation in flight normally presents little difficulty. When external visual cues are lost, however, the pilot must rely on the aircraft's instrumentation to provide him with the reliable and relevant information required to keep him oriented and to maintain control of his aircraft.

In such a situation, the pilot must be capable of suppressing conflicting sensory perceptions with respect to horizontal and gravitational references. While there is no guaranteed method, the successful suppression of this erroneous sensory information is directly related to training, time, and experience. Pilots inexperienced with instrument flying or pilots with little current instrument time are particularly susceptible to spatial disorientation when they are unexpectedly confronted with no external visual attitude references.

1.16.6 Risk Assessment

When a pilot successfully performs a work-related activity that involves risks, his attitude to or perception of the risks often changes. As he becomes more accustomed to and successful at performing hazardous tasks, he comes to believe that nothing will happen to him. He can diminish the perception of the risks and even begin to feel that these activities are not hazardous.

The feeling of security and self-confidence generated by this attitude encourages the person to repeat the risky activity. The more often he completes the task without adverse consequences, the more his feeling of security seems justified. And, as he is encouraged by this sense of invulnerability, the more he reduces his margin of safety and takes higher additional risks.

This belief will be reinforced if the pilot observes that others are performing the same manoeuvre; consequently, the procedure becomes the norm. The unfortunate irony is that, as the perception of risk decreases, the chance of an accident increases.

2.0 Analysis

2.1 Introduction

Based on factual information gathered during the course of the investigation, certain aspects of the occurrence flight are reliably known.

The helicopter commenced its flight in marginal visual meteorological conditions. The pilot intended to climb through a fog layer using rising terrain as visual reference during the climb. As the helicopter climbed the rising terrain northeast of its departure point, it was flying in an area of visibilities reduced to a few hundred feet in dense fog. Based on the ear witness observations, the helicopter did not climb above the fog layer. The helicopter was manoeuvring in the Mount Harry Davis area when the noise of the helicopter colliding with the terrain was heard. At some point prior to the accident, the helicopter entered a descent. The initiation of the descent, particularly if accompanied by a decrease in collective pitch, would have altered the sound pattern produced by the helicopter while in forward flight. This is consistent with the description by some ear witnesses of an absence of helicopter sounds prior to the sound of impact. At impact, the helicopter was heading in a southerly direction, essentially away from Mount Harry Davis and back towards its base in Houston.

There are two conditions which could account for the accident: a helicopter technical malfunction or the pilot inadvertently losing his visual references with the ground.

The analysis will examine these two possibilities and will review specific risk management circumstances surrounding the occurrence.

2.2 Technical Malfunction

The examination of the wreckage did not reveal any evidence of a pre-impact failure of the helicopter's engine, controls, or instrumentation systems. According to the technical logs, the helicopter had been properly maintained in accordance with existing regulations and there was no record of flight control difficulties.

The possibility that the particles discovered in the collective servo actuator had interfered with the spool valve during the accident flight and that such interference was causal to the accident was considered. Although three of the particles had clearly interfered with the spool valve at some point, it was impossible to determine specifically when during the 6000-hour life of the component the interference event had occurred. Nevertheless, as a result of the tests and analysis conducted, it was concluded that, if the interference had occurred during the accident flight, the force required to overcome the interference of the spool valve by shearing the particle was well within the pilot's capability.

Although an aircraft malfunction, particularly a jamming of the servo actuator's spool valve, could not be conclusively ruled out as the direct cause of the accident, such an event is regarded as improbable. It was considered more likely that the pilot lost visual reference with the ground at some time while manoeuvring in the vicinity of Mount Harry Davis.

2.3 Loss of Visual Cues

While flying in the operational and environmental conditions known to exist at the time, the helicopter pilot was at considerable risk of losing his external visual cues with the ground.

Given the high velocity and the flight profile at impact, it is reasonable to conclude that the pilot probably did not see the ground prior to the collision.

There are several elements present in this occurrence which could be considered as contributing to the loss of the pilot's outside references.

For example, the pilot intended to fly the helicopter in a climb up the side of Mount Harry Davis while the helicopter was at or near its maximum all-up weight. Although the helicopter was capable of hovering flight, the additional power margin required to continue the climb over the rising terrain was limited. The pilot could, therefore, have been intent on maintaining an airspeed at least above translational speed, which may have been too fast for the visibility conditions.

The flight could also have encountered an area where the ground features were uniformly covered with snow and frost. When combined with the poor visibility conditions, these circumstances could have resulted in a whiteout situation.

The conditions inside the helicopter may also have combined to further restrict the flight visibility. Given the existing temperature and dew point, and given that the warmly clad occupants were likely increasing the cabin's relative humidity level, it is possible that moisture condensed on the interior of the helicopter's windscreen. This would have impaired the pilot's vision to external references.

As previously discussed, given the discovery of the metallic fragments in the collective servo actuator, a control difficulty was a remote possibility which could not be conclusively ruled out. Such a technical problem could have caused the pilot to focus his attention inside the cockpit at a critical moment during the flight and resulted in his loss of visual reference with the ground.

All of the above could have resulted in or contributed to the loss of external visual references.

The reason for the pilot's probable loss of visual cues could not be determined. Whatever the reason, however, the pilot would have been faced with one of the most hazardous situations to be encountered in helicopter flying: that is, immediate transition from flight with visual reference to flight with reference to instruments. This would have occurred while in a critical phase of flight--close to the ground while in a high performance regime and in mountainous terrain.

2.4 Spatial Disorientation

The pilot in this occurrence had the added disadvantages of not being experienced or current in instrument flying, and flying an aircraft which was only marginally equipped for instrument flight. A pilot suddenly exposed to IMC flight under these conditions is known to be susceptible to spatial disorientation.

The high velocity and unusual yaw attitude at impact are indications of flight consistent with spatial disorientation.

2.5 Risk Management

It could not be determined why the pilot departed in marginal weather conditions and into flight visibilities he had earlier described as four or five tree-top lengths.

There was no evidence that the pilot was under pressure from the customers to complete the revenue flight. He intended to repeat the cloud-breaking procedure immediately after the accident flight for the purpose of a pleasure trip to go fishing with his friends.

The pilot had successfully flown a trip earlier that day in marginal weather. He had flown a similar flight the day before and, according to his entries in his log-book, he had flown in marginal weather conditions on a number of occasions. In addition, during his career flying in the mountains of British Columbia, he had undoubtedly observed other pilots doing the same. It is possible, given his previous success in completing the cloud-breaking procedure and given his awareness of other pilots using the same technique, that his sense of the dangers inherent in the procedure had been diminished. His comment earlier that day to the FSS specialist that the weather was "helicopter VFR" may have been a reflection of this perception.

3.0 Conclusions

3.1 Findings

1. The pilot was certified, trained, and qualified for VFR flight in accordance with existing regulations.

2. The pilot had extensive experience in mountain and marginal weather operations.

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

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

5. The helicopter was not certified or equipped for flight in instrument meteorological conditions.

6. Some metallic particles, originating from the component's manufacturing process, were found in the collective servo actuator.

7. Three of these particles bore evidence of having interfered with the movement of the spool valve at some time during the life of the component.

8. There was no evidence found of any airframe failure prior to or during the flight.

9. The pilot's intent was to climb above a layer of fog by using the rising terrain as a visual reference.

10. The visibility along the helicopter's flight path was reduced to 1/4 mile or less in fog.

11. While in the Mount Harry Davis area, the pilot was operating in flight visibilities which were below existing VFR criteria.

12. Prior to impact, the pilot had probably lost his external visual cues and the helicopter was likely in instrument meteorological conditions.

13. The pilot had successfully employed the technique of using rising terrain as a visual reference to climb above a fog layer on two other known occasions.

14. This technique is widely known in the helicopter pilot community; however, the frequency of its use could not be determined.

3.2 Causes

The pilot, while attempting to climb through a fog layer by using rising terrain as a visual reference, most likely lost the visual cues required for flight in visual meteorological conditions (VMC). The helicopter struck a ridge, probably while the pilot attempted to regain his visual reference with the ground.

The pilot's decision to use the rising terrain as a visual reference under the existing visibility conditions was a contributing factor to this accident.

4.0 Safety Action

4.1 Action Taken

4.1.1 Hydraulic Servo Contamination

On 15 December 1994, Transport Canada (TC) advised the Federal Aviation Administration (FAA) of the metallic contamination found in the helicopter's collective servo actuator. In their correspondence, TC suggested that the FAA ensure that the servo manufacturer takes appropriate quality control/assurance actions.

4.1.2 Interim TSB Aviation Safety Recommendations

Based on information compiled during this investigation, and frequent evidence of a lack of appreciation on the part of helicopter operators/pilots of the risks involved in conducting VFR flights into adverse weather, especially in mountainous terrain, the Board notified the Minister of Transport in August 1994 of three interim Safety Recommendations.

4.1.2.1 Flight Into Adverse Weather - Risk Awareness

A TSB safety study on VFR into adverse weather found that VFR-into-instrument-meteorological-conditions (IMC) accidents accounted for only 6% of the total number of aircraft accidents in Canada; yet, they involved 23% of all fatal accidents and took the lives of 418 persons between 1976 and 1985. Half of the VFR-into-IMC accidents had occurred in mountainous or hilly terrain; approximately 10% of VFR-into-IMC accidents involved helicopters, and one third of these were fatal. Since the release of the safety study and its associated recommendations in December 1990, there have been 10 commercial helicopter accidents in Canada involving VFR flight in adverse weather, resulting in six fatalities. The Board believes that some VFR-rated helicopter pilots, especially those operating in mountainous areas, have adopted the practice of intentionally penetrating localized areas of extremely reduced visibility in order to reach areas of better weather.

Commercial helicopter accidents in adverse weather continue, despite frequent emphasis in TC safety newsletters and presentations on the importance of adhering to established VFR limits. The Board believes that proper training and education are important in the prevention of adverse weather accidents; however, the Board was not aware of any substantial measures in this vein being taken by TC or the helicopter industry following the recommendations of its 1990 study. Therefore, the Board recommended that:

> The Department of Transport, in consultation with the aviation industry, implement a special safety campaign to inform the helicopter community of the inherent risks involved in the ad hoc practice of penetrating cloud/fog in VFR operations, particularly in mountainous regions.
> (A94-18, issued August 1994)

In its response to recommendation A94-18, TC has indicated that it will make extra efforts in this regard by publishing a feature article in the helicopter safety newsletter, *Vortex*; this newsletter is distributed to every licensed helicopter pilot in Canada. Also, Regional Aviation Safety Officers (RASOs) across the country will be provided with a special promotional package, so that they may distribute it to the helicopter industry during their regional visits.

4.1.2.2 Regulatory Compliance & Industry Self-Regulation

ANO V, No. 3, Para 6 does not permit VFR flight in cloud. The Board believes that the extent to which the unsafe practice of cloud penetration is prevalent might suggest a lack of respect for the need for regulatory compliance; operators/pilots may feel that there is only a remote possibility of being found in violation of the ANO. In a 1991 TSB survey of commercial pilots, 38% of respondents stated that TC's inspections of company facilities are not sufficiently frequent to ensure that regulations are respected. It is understood that Transport Canada has not recorded any violations under ANO V, No. 3, Para 6 in the mountainous regions of western Canada in the last ten years.

The Board is well aware that climatic conditions in many locations prevent some VFR-only operators from conducting their business at certain times of the year. However, if these operators ignore the weather limits in the ANO, they negate the safety buffer provided by the regulation, and put themselves and their passengers at risk. Furthermore, the Board believes that within the helicopter industry in general, the practice of "pressing-the-weather" is tacitly accepted and is viewed as a part of doing business. There does not appear to be self-regulation through condemnation by peers in this regard within the industry.

The Board believes that neither the regulator nor the commercial helicopter industry are effectively ensuring compliance with established weather limits. Therefore, the Board recommended that:

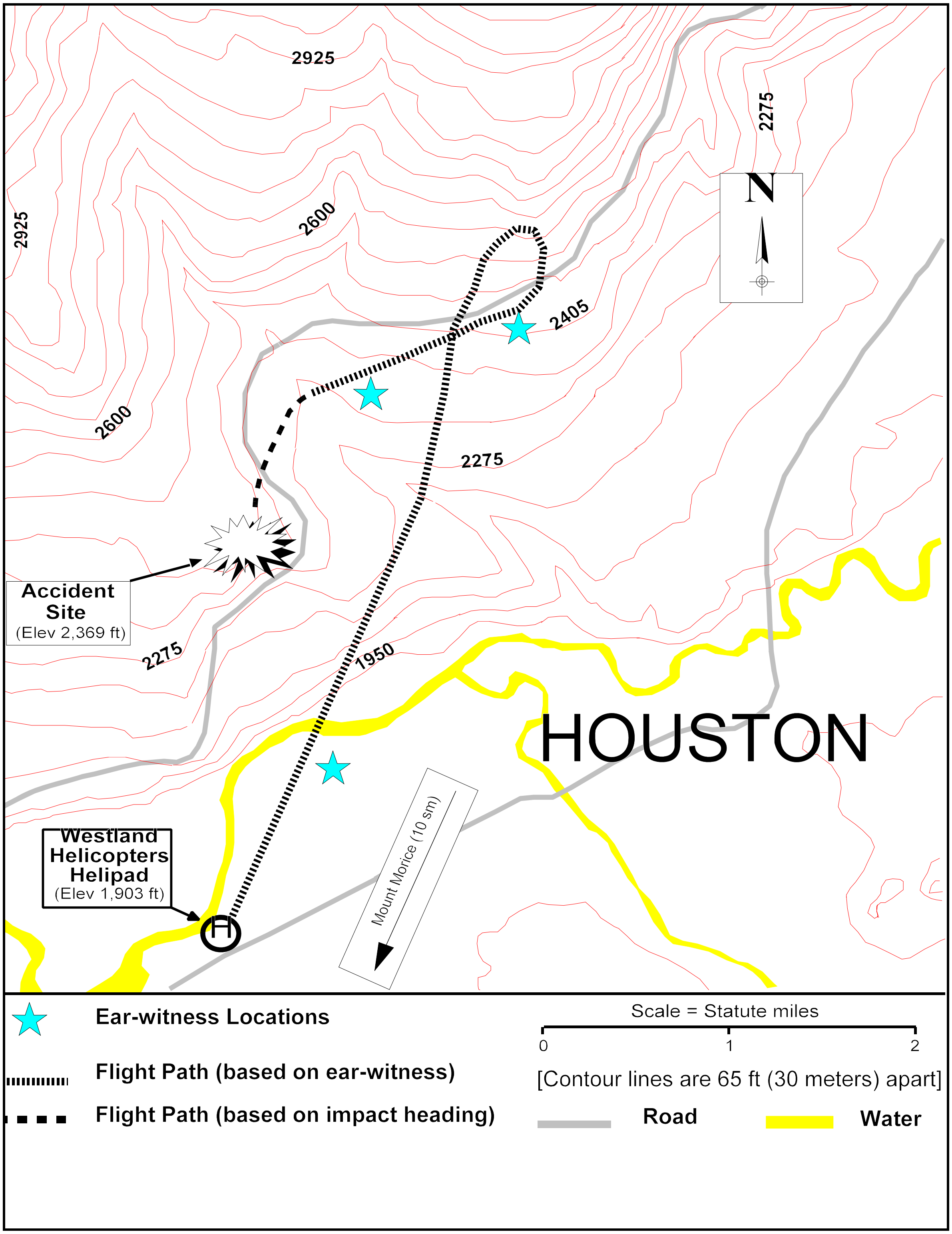
> The Department of Transport place increased emphasis on achieving compliance with respect to VFR weather limits for commercial helicopter operations; and
>
> (A94-19, issued August 1994)

> The Department of Transport, in conjunction with industry, explore measures to counter attitudes that "pressing-the-weather" is an acceptable practice in commercial VFR helicopter operations.
>
> (A94-20, issued August 1994)

In its response to recommendation A94-19, TC indicated that regional air carrier branches will be tasked to place increased emphasis on commercial helicopter operations in adverse weather conditions and that an Air Carrier Advisory Circular (ACAC) will be issued emphasizing the hazards of intentionally penetrating localized areas of reduced visibility. With respect to recommendation A94-20, TC indicated that a letter will be sent to the major helicopter associations to impress upon their members that "pressing-the-weather" is not an acceptable practice.

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 Hugh MacNeil, authorized the release of this report on 05 July 1995.

Appendix A - Estimated Flight Path



Appendix B - List of Supporting Reports

The following TSB Engineering Branch Laboratory reports were completed:

LP 28/94 - Crash Analysis;

LP 35/94 - Instrument/Light Bulb Analysis;

LP 80/94 - Hydraulic System Contaminant; and

LP 85/95 - Control Components Examination.

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

Appendix C - Glossary

AES	Atmospheric Environment Service
AIP	Aeronautical Information Publication
ANO	Air Navigation Order
asl	above sea level
ATS	Air Traffic Services
AUW	all-up weight
ELT	emergency locator transmitter
FOD	foreign object damage
fpm	feet per minute
FSS	Flight Service Station
IMC	instrument meteorological conditions
knots	nautical miles per hour
MHz	megahertz
PEP	Provincial Emergency Program
PST	Pacific standard time
RCC	Rescue Coordination Centre
TC	Transport Canada
TSB	Transportation Safety Board of Canada
UTC	Coordinated Universal Time
VFR	visual flight rules
VMC	visual meteorological conditions
'	minute(s)
"	second(s)
°	degree(s)
°M	degrees of the magnetic compass
°T	degrees true