TSB Recommendation A90-83

Radar altimeters

The Transportation Safety Board of Canada recommends that the Department of Transport / require all helicopters engaged in commercial passenger carrying operations be equipped with radar altimeters.

Air transportation safety investigation report	90-SP002
Date the recommendation was issued	13 November 1990
Date of the latest response	August 2017
Date of the latest assessment	March 2024
Rating of the latest response	Unsatisfactory
File status	Dormant

Summary of the occurrence

Accidents in which the aircraft was operated under Visual Flight Rules (VFR) into adverse weather conditions occur regularly, claiming a disproportionately high number of fatalities each year. They involve professional pilots, private pilots and business pilots who fly general aviation aircraft and chartered commercial aircraft, including fixed-wing aircraft and helicopters.

The regularity with which these accidents have occurred, and the seriousness of the continuing loss of life, prompted the Canadian Aviation Safety Board (CASB) to initiate a comprehensive and systematic examination of the issue. In March 1990, when this report was nearing completion, the CASB was replaced by the Transportation Safety Board of Canada (TSB), under whose auspices this report was published on 13 November 1990.

During the last two decades, a number of foreign government agencies have undertaken measures to more fully understand these types of accidents. Recent studies emphasize both the complex decisional nature of continued VFR flight into adverse weather and the often fatal consequences. This safety study is the first comprehensive review of the topic in Canada in recent years, and builds upon these earlier works.

The Board authorized the release of recommendation A90-83 as part of its report entitled *Report of a Safety Study on VFR Flight into Adverse Weather* (90-SP002) on 13 November 1990.

Rationale for the recommendation

Analysis of the accidents revealed few equipment deficiencies for either fixed-wing aircraft or helicopters. However as noted earlier, 27 of the 33 helicopter accidents occurred in whiteout conditions, and many of these occurred while in controlled flight. Many VFR-into-IMC [1] helicopter accidents occurred as a result of inadvertent descent while flying over featureless terrain in conditions that often made it impossible for the pilot to accurately determine the altitude of the aircraft above the ground. Such descents could have been detected by the pilot if the aircraft had been equipped with an automated warning device, such as a radar altimeter, to signal the pilot of the ground's proximity. Only two accident helicopters were equipped with radar altimeters. In light of the conditions encountered in many of the helicopter accidents, where inadvertent descents were undetected by the pilot, the Board recommended that

> The Department of Transport require all helicopters engaged in commercial passenger carrying operations be equipped with radar altimeters.
>
> **TSB Recommendation A90-83**

Previous responses and assessments

March 1991: response from Transport Canada

Transport Canada (TC) responded to this recommendation by simply stating that this issue would be addressed by TC's VFR Working Group.

May 2005: TSB assessment of the response (Unsatisfactory)

In its March 1991 response to TSB, TC stated that Recommendation A90-83 would be referred to a VFR Working Group for further action. Subsequently, in a July 1993 update, TC stated that its VFR Working Group had reviewed Recommendation A90-83 and concluded that the recommendation not be adopted. They stated that radar altimeter installations provide minimal practical benefit to a pilot who should be maintaining visual reference and that any benefit was far outweighed by the high cost of installation and maintenance. TSB staff appreciated the real financial burden to operators in this economic climate; however, maintained that the basic argument for protection against inadvertent descents in IMC provided by a radar altimeter installation remains.

Based on TC's position, TSB's initial assessment was rated as **Unsatisfactory** and a Deficiency File Status of **Active** was assigned**.** Throughout the years, TSB was to monitor the risks associated with the deficiency identified in Recommendation A90-83 for trends. As the residual risks remained and TC's position did not change, in that no action was taken or proposed that would reduce or eliminate the deficiency, subsequent reassessment ratings remained as **Unsatisfactory**.

---

[1] Involving an aircraft governed by Visual Flight Rules (VFR) which initiated or continued flight into Instrument Meteorological Conditions (IMC)

The last recorded reassessment of TC's response to A90-83 dated 11 May 2005 stated the following:

> A search of TSB data for VFR-into-IMC[2] accidents in Canada for the years 1995 to 2004 inclusive produced 74 occurrences, which upon cursory review, seemingly met the criteria of "continued VFR flight into adverse conditions". These occurrences accounted for approximately 2.3% of the total occurrences (3252); also there were 41 fatalities in these occurrences compared to the total of 679 fatalities (approximately 6.0%). Fewer than 42% of the 74 accidents (31) involved private/recreational aircraft; of the remainder, 42 involved commercial operations, and one was corporate. [Of note, the statistics from the earlier TSB study were: 6% of all accidents were the VFR-into-IMC type, and these accounted for 26% of all fatalities.]
>
> Transport Canada and the helicopter industry have not taken the specific action as recommended by TSB. Yet many of the action/initiatives taken by Transport Canada and the aviation community to prevent VFR-into-IMC accidents in general would apply to helicopter flying. Recent data (1995-2004), however, shows that occurrences with helicopters flying in adverse weather conditions continue to happen (14 out of 74 accidents were helicopters). It could not be determined if the underlying unsafe conditions for these recent accidents would have been rectified by the action specified in A90-83, therefore, the assessment remains as "Unsatisfactory".
>
> Notwithstanding, given that the data used to support A90-83 is now more than 20 years old, the TSB will, through ongoing and/or future investigations, attempt to better define the nature of the unsafe conditions behind the continued helicopter VFR-into-IMC accidents, and if necessary, make "new" recommendations. As such, "Further Action is Unwarranted" with respect to A90-83 and the Status is set to "Inactive".

Consequently the assessment was rated as **Unsatisfactory** and assigned an **Inactive** status.

October 2010: Board review of deficiency file status

The Board requested that all inactive aviation recommendations with an assigned rating other than **Fully Satisfactory** be reviewed to determine if their Deficiency File Status was appropriate. After an initial evaluation, it was decided that several such recommendations required that a deficiency analysis update be conducted to confirm if the associated risks remained substantial.

October 2011: deficiency analysis update

The TC VFR Working Group (convened specifically to review several of TSB's *VFR Flight into Adverse Weather* study recommendations) concluded that requiring radar altimeters be

---

[2] Involving an aircraft governed by Visual Flight Rules (VFR) which initiated or continued flight into Instrument Meteorological Conditions (IMC)

installed on all commercial helicopters would have a high cost impact. Additionally, the minimal practical benefit to a pilot, who should be maintaining visual reference, was far outweighed by the high cost of installation and maintenance.

Since the reassessment of 2005, TSB data show that continued VFR flight into adverse weather remains a significant threat to aviation safety. While VFR-into-IMC accidents account for a relatively small portion (less than 10 per cent) of all reported accidents, approximately 55 per cent of those VFR-into-IMC accidents were fatal, compared to 10 per cent of all other accidents.

Specifically, TSB's aviation database revealed 63 helicopter accidents from 2005 to the present for which reports were published. Of the 63 reports produced, 4 reports (or 6.3%) involved "continued VFR flight into adverse weather conditions". All but 1 occurrence resulted in a fatality, for a total of 4 fatalities.

In the years since its last assessment of TC's response to Recommendation A90-83, TSB has performed several investigations involving helicopters flying into whiteout conditions. However, no findings were published that cited the absence of a radar altimeter as being a risk factor in these occurrences.

Intuitively, a radar altimeter would appear to greatly improve a pilot's awareness of height above the ground during hover, landing in unimproved landing zones (rough field landings), and landings in confined areas where a more vertical approach may be required. Additionally, radar altimeters help increase situational awareness during inadvertent flight into IMC, night operations, and flat-light, whiteout, and brownout conditions. In all of these conditions, pilots lose their reference to the horizon and to the ground. Anecdotally, a serviceable radar altimeter, properly used, would seem to be a net benefit when a helicopter encounters inadvertent IMC. Unfortunately, statistics do not exist for those helicopters which flew out of IMC conditions aided by the use of a radar altimeter.

Since TSB Recommendation A90-83 was issued, similar risks have been identified by the National Transportation Safety Board (NTSB) resulting in the following safety recommendation being issued to the Federal Aviation Administration (FAA):

> Recommends that the FAA require the installation of radio altimeters in all helicopters conducting commercial, passenger-carrying operations in areas where flat-light or whiteout conditions routinely occur.
>
> (A-02-35)

On 12 October 2010 the FAA, assisted by members of the US helicopter industry, recognised the inherent benefit of a radar altimeter on a commercial helicopter by issuing a Notice of Proposed Rulemaking (NPRM) entitled *Air Ambulance and Commercial Helicopter Operations* that will, if adopted, require all commercial helicopters be fitted with radar altimeters. If such a requirement is adopted, whether or not Transport Canada harmonizes with the FAA in this respect remains to be seen.

Presently, the risks associated with VFR flight into adverse weather remain substantial and TC has not indicated that it plans any action to reduce the risks associated with commercial helicopters continuing to fly without benefit of radar altimeters. Consequently the reassessment remains as **Unsatisfactory.**

Given the developments in the U.S., the Board believes that this recommendation warrants TC's further consideration. Therefore, the deficiency status is changed to **Active**.

October 2011: next TSB action

Consequently, TSB staff will follow-up with TC to determine if further action will be taken to reduce the risk.

December 2011: response from Transport Canada

Upon receipt of the latest A90-83 reassessment document, TC sent a letter to Director, Air Investigations Branch containing the following:

> This is in response to your letter of November 2, 2011, to the Director General, Civil Aviation.
>
> Transport Canada Civil Aviation (TCCA) requests a meeting with the TSB to fully understand the intent of the recommendations. Following this meeting, a focus group will be formed to review the recommendations and conduct a risk assessment. TCCA anticipates that the review and risk assessment related to these recommendations will be completed for the TSB's annual reassessment in 2012.

TSB staff was able to liaise with TC and clarify the Board's position regarding the deficiency identified in Recommendation A90-83. Subsequently, on 12 January 2012, TC withdrew its request for a meeting and stated that a formal response would be forthcoming.

May 2012: response from Transport Canada

TC's formal response was written as a composite response providing update on its position for both recommendations A90-81 and A90-83. The letter contained the following:

Transportation Safety Board of Canada Recommendation A90-81

The Department of Transport require verification of proficiency in basic instrument flying skills for commercially-employed helicopter pilots during annual pilot proficiency flight checks.

Transportation Safety Board of Canada Recommendation A90-83

The Department of Transport require all helicopters engaged in commercial passenger carrying operations be equipped with radar altimeters.

Background

Transport Canada believes these recommendations were intended to redress the ongoing problem of helicopters being operated under visual flight rules (VFR) which inadvertently entered instrument conditions and then suffered loss of control accidents. The rationale was that basic instrument checking for those skills during the annual PPC, and the addition of a radar altimeter might assist pilots who had entered this flight regime to maintain control of their aircraft and leave the instrument conditions. These types of accidents currently comprise approximately 10 % of the annual Canadian-registered helicopter accidents. Of that 10%, approximately 50% result in fatalities, therefore the concern for the issue is legitimate.

The original analysis from the early 1990's rejected both Recommendations on the basis that incorporating these actions as regulatory changes would be an ineffective solution for the problem and expensive for the operators to implement.

Analysis

The term inadvertent instrument conditions, suggests that instrument conditions somehow suddenly surprise the pilot, and the pilot was unsuspecting up to that point. The reality is quite different. Helicopter pilots are not suddenly surprised that the weather has become bad. The common scenario is as follows; the pilot begins the flight with the knowledge that the weather along the route is limited, and contains areas of low ceilings and or low visibilities. In these days of proliferating computer technology, there are few places where basic weather forecasting is not available before a flight commences. Even without a forecast, the fastest of helicopters will allow the pilot to see the weather ahead is marginal, long before the aircraft gets close to the obscuration layer or front.

The problem lies with the helicopter's inherent unique low speed capabilities and the pilot decision-making process. The pilot is able to slow down to a walking pace, or slower, and to drop down to a very low altitude, and then creep along – hopefully to a place where the weather improves. In this fashion, the pilot may fly using visual techniques in conditions that would be unacceptable – too low in uncontrolled airspace -for instrument flight. The danger that exists is that the pilot may then suddenly lose all outside reference, due to a further drop in the weather, and that is when he becomes trapped in instrument conditions.

When this happens, several issues converge and interact simultaneously and the aircraft is now in imminent danger of a severe accident. The helicopter is already close to the ground, and being operated at a very slow speed with unknown obstacles in the vicinity. A large power change is a typical response to avoid hitting the ground. The helicopter may actually stop all forward motion, and may move sideways, backwards or straight up, further into the clouds. Helicopters are dynamically and statically unstable, and react very quickly to control inputs, particularly in the roll axis. Any turn can quickly become excessive, and the helicopter will tend to fall as the nose drops during the turn. The pilot will be fighting rising panic, with very little time to react, and generally, without any recency in instrument flight.

The suggested procedure is to make a 180 degree turn, without banking too quickly, and without climbing or descending, while maintaining airspeed. That is a lot to ask in an unstabilized helicopter, with a panicking pilot not current on instruments. Unfortunately, if the helicopter has been pushing along in low weather for some time, there is no guarantee that better weather lies behind the helicopter, and any extended period spent in the clouds exacerbates the likelihood of a loss of control, following the emergency 180 degree turn.

Because the helicopter was being flown by visual reference at the time the references were lost, it is very difficult to transition to instruments. A scan must quickly be established to ensure airspeed, altitude, rate of turn and power application is appropriately maintained, all while realizing that you are very close to the ground and that you might strike a tree or cliff face while reversing course on instruments.

Finally, current Canadian regulations do not require day VFR aircraft to be equipped with basic instruments that are necessary to accomplish these manoeuvres. Attitude indicators, vertical speed indicators, turn and bank indicators and directional gyroscopic equipment are not mandated by current regulation for day VFR aircraft. To incorporate the recommendations as written, it would be necessary for all commercial helicopters to have these devices installed, as well as automatic stabilization, to reasonably accomplish the safety objective for an emergency escape from instrument conditions. This would have the effect of greatly increasing costs to operators, as this equipment would have to be purchased, installed and maintained, which would then result in a reduction in useful load for the aircraft, plus additional training and checking costs for all of the pilot staff.

FAA Initiatives

The TSB has raised the issue that the FAA are considering the implementation of these requirements in the American rules, for medevac and commercial operations and that harmonization might be a legitimate consideration for TC. It should be noted that the Americans have two areas of helicopter activity where their accident rate is well above the global and Canadian norms – emergency medevac operations and helicopter sight-seeing operations, particularly in Hawaii.

U.S. Medevac operations

The American medevac industry differs significantly from the Canadian model: In the U.S., medevac helicopters are attached to individual hospitals for the most part, and become a revenue generator and cost centre for the hospital facility they serve. They attend on-scene calls and are not restricted in the use of single engine helicopters being flown by single pilots, even at night. This policy has resulted in numerous fatal accidents over the past 20 years. As well, several U.S. night medevac helicopter accidents have occurred with twin engine helicopters being self-dispatched and flown by a single pilot.

In Canada, almost all operations require two pilots in a twin engine helicopter with operations conducted in accordance with instrument procedures criteria. Further, Canadian operations are dispatched and controlled by central medical agencies, and hospital profitability is not

considered in the equation. The FAA met with the NTSB in meetings in Washington in 2009 to discuss what needed to be changed. Canadian medevac operations were discussed, but rather than adopting the successful and safe Canadian model, the U.S. have chosen to increase the technology carried in their helicopters, rather than restricting the types of helicopter that can be operated in these conditions.

It should be noted that Canada has only suffered one dedicated medevac accident which resulted in injuries since the inception of this service in the mid-1970's. Harmonization for this aspect of Canadian operations would have no useful purpose.

U.S. Sightseeing operations

There have been numerous helicopter sightseeing accidents in recent years, particularly in Hawaii. The problem is continuous low cloud formations building over volcanic, mountainous areas. Sightseeing helicopters carrying tourists attempt to transition these areas, and periodically lose visual reference and strike cliff faces with catastrophic results. There is pressure to proceed with the flights, as this is the primary source of revenue for these companies, but once again, failure to respect the existing FAA regulatory weather limitations and pressing on in the face of obscuring phenomena are the primary cause of these accidents.

Specific Issues

1. The Regulations:

> DIVISION II - AIRCRAFT EQUIPMENT REQUIREMENTS
>
> Power-driven Aircraft - Day VFR
>
> 605.14 No person shall conduct a take-off in a power-driven aircraft for the purpose of day VFR flight unless it is equipped with
>
> (a) where the aircraft is operated in uncontrolled airspace, an altimeter;
>
> (b) where the aircraft is operated in controlled airspace, a sensitive altimeter adjustable for barometric pressure;
>
> (c) an airspeed indicator;
>
> (d) a magnetic compass or a magnetic direction indicator that operates independently of the aircraft electrical generating system;

Note: These are the only flight equipment instrument requirements for a day VFR helicopter. A commercial operator may have helicopters with additional equipment, but there is no requirement to maintain such instrumentation on board. Entering inadvertent instrument conditions with the basic equipment mandated by current Canadian regulations would not permit the pilot to control the aircraft by sole reference to the instruments, no matter what training had been done.

2. The Aircraft Certification

Most helicopters do not meet the stability criteria necessary for instrument flight capability without the addition of an autopilot. Unless that equipment is added, they are approved for VFR

flight only, and in some cases, night VFR. To meet the instrument conditions stability requirements, automatic stabilization is normally a mandatory addition.

Operators do not add these devices because the aircraft may be operated under VFR conditions without any limitation, and the addition of any equipment to the basic airframe results in a weight penalty that reduces the range of the aircraft and the useful load that may be carried.

Should a pilot venture into inadvertent instrument conditions without stabilization, he must fly the aircraft in a flight realm that has been demonstrated not to meet mandatory certification criteria, while in an emergency situation. It is obvious that the chance of a successful outcome from this scenario is poor.

3. Aircraft Capability

Helicopters all have fuel range limitations when compared to similar fixed-wing counterparts. After entering instrument conditions, most helicopter pilots do not have the option of climbing to altitude and flying to an instrument equipped airport. Helicopters, for the most part, do not have icing equipment beyond the rudimentary engine anti-ice, and the pilots will not have approach plates, maps or fuel range to conduct a let-down.

As well, helicopter instrumentation such as airspeed is based on fixed-wing instruments. Helicopters operating at low air speeds typical at the time of a loss of visual references will experience inaccurate readings of pitot static equipment due to rotor downwash below 20-30 knots, and may show zero airspeed at a critical juncture during the emergency.

4. Pilot limitations

Most companies in Canada operate under VFR Operating Certificates, and almost all of this work is conducted during daylight hours. Unlike fixed wing operations, many helicopter pilots never get instrument ratings throughout their careers, because IFR operations are very limited in scope in Canada.

Accordingly, many VFR pilots do not become familiar with the flight instruments on their panel, to the point where they can fly by reference to instruments alone. When faced with an emergency which requires the use of instruments, it is easy to understand why these pilots would be hesitant to try to transition to an unfamiliar system, when their career has been based on a visual control system. The helicopters are generally at very low altitude when references are lost, so the time to transition to instruments before an accident is exceedingly short. Even with annual training and a check procedure in place, a once a year exposure to limited instrument practice and a single check is unlikely to translate into necessary competence in a dire emergency.

5. Company limitations

Currently, there are two systems of flight checks in place in Canada for CAR 703 operators- the Pilot Proficiency Check, conducted by an approved check pilot (ACP) and a Pilot Competency Check (PCC) which may be administered by the Operator's Chief Pilot or his delegate.

In either case, an operator may not have personnel on staff capable of conducting instrument training, or access to an ACP with appropriate instrument qualifications. As mentioned previously, the same operator may not have a helicopter with adequate instrument equipment to conduct either the training OR the check ride, while still fully in compliance with the existing Canadian Aviation Regulations.

Conclusion

Inadvertent penetration of instrument conditions has three primary scenarios and causes: low cloud, fog encountered during the flight and white-out or brown-out encountered on landing or take off. White-out may also occur in cruise flight, should a pilot fly out over a large frozen body such as a lake where the horizon is indistinct. Again, there should be adequate visual cues and discomfort, so that the pilot has some forewarning of the danger. When the horizon becomes obscured, or visual cues are indistinct or few, the pilot will have difficulty maintaining level flight, or may oscillate in pitch attitude. These signs should serve as an early warning and appropriate action should be taken.

There are strategies for avoiding white-out or brown-out conditions that rely on pilot awareness and techniques when dealing with these phenomena, and avoidance of inadvertent penetration of instrument conditions by turning back early or delaying flights until conditions meet the regulatory requirements for visual flight in uncontrolled areas. Applying these techniques prevents accidents and saves lives. From the decision-making literature we know that recognition of the hazard and knowing what to do about it are critical to selecting the correct option.

Operating in accordance with the existing VFR regulations and respecting the certification basis for the helicopter is imperative to prevent these accidents from happening. Education and avoidance are the key elements to reducing these accidents. Operators, who insist that their pilots not “press on” in bad weather and support those decisions, are less likely to suffer an accident.

Transport Canada’s response to Transportation Safety Board recommendations A90-81 and A90-93

Transport Canada’s current analysis has not changed from its original position; the current strategy for pilot avoidance of the phenomenon is the obvious and most effective means of preventing these accidents. The only reasonable approach is to ensure operators and pilots observe the existing limitations of the Canadian Aviation Regulations and the basis of certification for their helicopters.

September 2012: TSB assessment of the response (Unsatisfactory)

TSB does not dispute TC's contention that "inadvertent" VFR into IMC events constitute a small percentage of the total VFR into IMC events. However, TSB believes that given the fatality rate of these events, TC's efforts to date to reduce the causes of VFR into IMC events are inadequate. Consequently, Recommendation A90-83 concerns itself with providing helicopter pilots with a radar altimeter to act as an automated warning device designed to assist pilots in extricating themselves from a VFR into IMC situation.

The response states the CARs requirement for equipping day VFR helicopters with an altimeter in uncontrolled airspace and a sensitive altimeter, adjustable for barometric pressure, for use in controlled airspace. Other than some non-specific comments regarding additional expenses to be incurred by equipping helicopters beyond current requirements, the response does not discuss the merits of using a radar altimeter versus a barometric altimeter in dealing with inadvertent descent during a VFR into IMC situation.

TC's comparison between the U.S. and Canadian commercial helicopter experience operating under VFR into IMC focuses on the limitations of the U.S. air ambulance and a regional sightseeing phenomenon. The FAA's NPRM, referred to in TSB's assessment, is entitled *Air Ambulance and Commercial Helicopter Operations,* and the referenced NTSB recommendation calling for radar altimeters resulted from accidents under flat light conditions involving commercial helicopters.

Currently, the risks associated with VFR flight into adverse weather remain substantial. While TC agrees that, given the fatality rate, the issue is legitimate, it plans no action to reduce the risks associated with commercial helicopters continuing to fly without benefit of radar altimeters as described in Recommendation A90-83. Consequently, the Board reassessment remains as **Unsatisfactory**.

The Board has determined that as the residual risk associated with the deficiency identified in Recommendation A90-83 is substantial and because no further action is planned by TC, continued reassessments likely will not yield further results.

The deficiency file is assigned a **Dormant** status.

Latest response and assessment

August 2017: response from Transport Canada

In 1990, the TSB published the report on a study of accidents involving Visual Flight Rules (VFR) flights that entered Instrument Meteorological Conditions (IMC). The report included

three recommendations to reduce the incidence of Controlled Flight Into Terrain (CFIT) by commercially operated helicopters.[3]

This recommendation is related to two other TSB recommendations. All attempt to reduce the incidence of CFIT accidents.

> A90-81 The Department of Transport require verification of proficiency in basic instrument flying skills for commercially-employed helicopter pilots during annual pilot proficiency flight checks.
>
> A90-83 The Department of Transport require all helicopters engaged in commercial passenger-carrying operations be equipped with radar altimeters.

The recommendations apply to light helicopters which are certified for VFR flight only. TC referred the recommendations to the VFR Working Group under the Canadian Aviation Regulation Advisory Council (CARAC). The Working Group recommended that TC not adopt the recommendations, concluding that their adoption would impose extremely high cost with no return in terms of risk reduction. The Working Group believed that far more can be accomplished by providing continuing education and training in pilot decision making, mountain flying and whiteout.

There are two schools of thought on how to reduce the risk of helicopter collision with terrain due to loss of visual references. Some believe that learning and occasionally practising basic instrument flying skills will allow a pilot to retain control of the helicopter long enough to return to Visual Meteorological Conditions (VMC). Others believe that the best option is to avoid IMC since the aircraft are too unstable to be reliably controlled by a pilot who possesses only basic Instrument Flight Rules (IFR) skills and is not current.

While TC supports the reduction of CFIT accidents, internal evaluation and consultation with industry concluded that requiring helicopter pilots to acquire minimal instrument flying skills is not a safe or effective option. The positions of both agencies (TC and TSB) have not changed in the past 27 years. The arguments on both sides are summarized well in TSB Report A96W0072 (p. 4).

The risk

Although relatively rare, helicopter CFIT accidents are particularly serious because the fatality rate in these accidents is quite high. Typically they occur at night or in conditions of reduced visibility. Most of the helicopters in Canada are certified for VFR flight only. These rules require the aircraft to be navigated and controlled by visual reference to features outside the cockpit.

---

[3] All responses are those of the stakeholders to the TSB in written communications and are reproduced in full. The TSB corrects typographical errors and accessibility issues in the material it reproduces without indication but uses brackets [ ] to show other changes or to show that part of the response was omitted because it was not pertinent.

Appropriately equipped aircraft can also be navigated and controlled by reference to instruments and displays inside the cockpit. This is called instrument flight and is regulated by IFR.

People use several sensory systems to orient themselves in space. Kinesthetic systems tell us where our limbs are in relation to the body and to each other. Vestibular organs in the ear sense acceleration in three dimensions, telling us which way is up. Vision is a very strong cue to spatial orientation. When external visual cues are absent, due to lack of light or obscured vision, humans are subject to illusions. These are perceptions that do not match objective reality and in flight can be fatal.

University of Illinois researchers placed pilots without instrument ratings in a flight training device. The experimenters took away all external visual references, a situation like sudden inadvertent entry into IMC. All lost control. The average time from loss of visual reference to Loss of Control (LOC) was 178 seconds[4].

IFR flight requires extensive training and practice. Pilots must learn to trust the instruments, regardless of what they are perceiving at any time. Controlling an aircraft by reference to instruments requires a pilot to:

1. Observe the displays;
2. Interpret each display;
3. Integrate the information to form an understanding of the current situation (altitude, airspeed, bank, and pitch at a minimum); and
4. Project into the future (What must I do to achieve goal?).

Flying solely by reference to instruments is a complex skill, subject to rapid decay unless practiced regularly. If pilots normally fly under VFR, one cannot assume that they can transition to instrument flight in a situation where the window for successful recovery is a matter of a few seconds and the aircraft is already not under control.

Helicopters and IFR flight

More than 80% of commercially operated helicopters in Canada are approved for day or night VFR operations only, and are equipped with the instruments required by regulation for that role. Most of the Canadian registered helicopters are single-engine types and the *Canadian Aviation Regulations* (CARs) do not permit single engine helicopters to fly in IFR conditions or VFR at night with passengers. (CAR 703.22/CASS 723.22 refers.)

Single main rotor helicopter models are inherently unstable, both statically and dynamically, and these aerodynamic qualities demand that a helicopter that is intended for use in instrument conditions must also be equipped with a stabilization augmentation system / autopilot at

---

4 TC. Take Five ... For Safety. (TP 2228). https://tc.canada.ca/en/aviation/publications/take-fivefor-safety-tp-2228

minimum, to supplement the instruments needed to fly under instrument conditions. Without a stabilization system, a pilot facing a sudden loss of visual references would be forced to immediately transition to instruments without autopilot assistance to maintain pitch, roll and yaw control; a difficult skill that is not practiced regularly in an aircraft intended for VMC flight only and that also cannot be certified for instrument flight lacking this equipment.

Stabilization augmentation systems require airframe and flight control modifications, approvals, installation, maintenance, flight procedure changes and pilot training. Additional cockpit instruments for stabilization system monitoring and control and aircraft performance and navigation are also required to permit the pilot to fly in instrument conditions. Stabilization systems and additional IFR cockpit instruments add weight, costs and operational complication, reduce useable payload and are not required for VMC-only flight. VFR operators currently do not install these integrated systems for these reasons.

Because the performance instrumentation is based on aeroplane pitot static systems, the helicopter must be flying forward at a minimum speed to permit control and ensure accurate information is displayed. This minimum instrument flight speed is designated “Vmini” and is typically 60-70 knots or more Indicated Air Speed (lAS). Most helicopter inadvertent IMC accidents occur at low airspeeds, well below Vmini. Accordingly, a pilot who has lost visual references would first have to accelerate to Vmini with limited or even contradictory input from the autopilot due to the effects of rotor downwash on the pitot system and resulting erroneous air data computer inputs.

The most common scenarios for helicopter inadvertent IMC accidents are:

- on takeoff or approach, where recirculating air blown by the main rotor causes a loss of references in loose snow (sometimes called the snowball);
- whiteout, which happens during flight over areas where the horizon is no longer discernible; and
- penetration of a weather system where the visibility and ceiling is seen to be getting worse, but the pilot continues into it at ever-decreasing altitude and airspeed.

Whiteout on approach or departure occurs very close to the ground, at speed well below Vmini, and generally provides little or no time for recovery. These accidents typically result in a rollover. The instrumentation is affected by rotor downwash at lower speeds, and the autopilot cannot respond correctly to the corrupted inputs from turbulent airflow. As well, sideways or backward flight cannot be detected on the instruments.

Whiteout that occurs in cruise flight is subtle, and although the aircraft may be at a speed above Vmini, the pilot is generally not aware of a gradual descent into the ground until contact is made, at which time it is too late for any recovery manoeuvre.

Loss of visual references caused by continuing into an area where visibility and ceiling are obviously decreasing is also subtle. Pilots quickly get used to flying lower and more slowly during the flight. As they progress, there is a strong tendency to continue and attend to cues

that support continuation while ignoring or discounting cues that indicate a change in plan is warranted. They may then enter an area where all visual references are suddenly lost, typically at very low speed and altitude. At that point, it is very difficult to transition to unpracticed, non-recent instrument flight. All of these emergency situations will be worsened by inevitable stress and, possibly, panic.

Unless able to regain VMC quickly, the pilot will need to transition to instrument flight, climb to a safe altitude and eventually conduct an instrument approach at a known facility within reach of the helicopter's fuel range. In many areas of Canada, this option does not exist, and it is unlikely that the necessary approach plates and route charts would be carried onboard. Some advocate a 180° turn to return to VMC, but there is no assurance that VMC still exists and the turn is a very challenging manoeuvre. At low speed, with non-functional instruments and lacking a stability augmentation system, a 180° turn without visual references would most likely lead to a LOC.

The accident record

The preceding discussion of single engine helicopters and IFR flight represents TC's long-held position on the issue. TC has always believed that the most effective way to prevent collision with terrain accidents is to avoid flight into IMC. To test this position and support a comprehensive evaluation of Recommendation A90-84, the Aviation Safety Analysis and Commercial Flight Standards Divisions undertook a comprehensive review of helicopter accidents involving collision with the surface. The purpose of this review was to determine whether installing instruments and requiring periodic verification of basic instrument flying skills would have prevented accidents. A search of the Aviation Safety Information System (ASIS) identified 465 helicopter accidents characterized as collision with terrain between 1988 and 2016 inclusive. The analysts were able to locate and review 55 investigation reports (Class 3, 2, or equivalent).

Results

Accidents were grouped according to salient features. The following grouping were identified:

- Engine failure 57;
- Unknown 8;
- Visibility related collision with terrain 68; and
- Collision with terrain not related to visibility 332.

Collisions with terrain following an engine failure were assessed as unrelated to visual references and were eliminated from further consideration.

There were five accidents where there was insufficient information to determine what likely led to the accident. These were eliminated from further consideration.

The bulk of the occurrences had enough information to support reasonable conclusions about the accident and whether instrumentation and IFR training were likely to have changed the

outcome. These were all analyzed. Of these, 332 were found to be unrelated to visibility and 68 occurred in reduced visibility or challenging light conditions. Many of the non-visibility related collisions with terrain included rotor strikes in confined areas or descending under power in VMC.

"Other" occurrences were unique, but unrelated to visibility. For example, one collision with terrain happened because a jacket became entangled with the tail rotor pedals. In another case control was lost when a passenger put weight on a skid during a toe-in landing. Visual references were poor, but the LOC was not due to visibility.

Each of the 68 visibility-related collisions with terrain occurrences was then assessed by a human factors specialist and an experienced helicopter pilot to determine whether the presence of instruments and basic skills could have prevented the accident. Final investigation reports were available for 16 of these accidents. The remainder were assessed on the basis of the narrative summary included in the ASIS long report.

Eight accidents occurred when the visibility was below the regulated minimum for VFR flight. Since the object of this analysis is to determine how many accidents are likely to be prevented by requiring more instrumentation and requiring annual demonstration of instrument skills, accidents resulting from wilful violations of minimum visibility regulations were eliminated from further analysis. These cases are identified in Table 1.

Table 1. Wilful violations of minimum visibility regulations

Occurrence Number	Summary
A94H0001	Wilful violation. Flew into IMC in heavy snow.
A94Q0182	Wilful violation. Medical evacuation. Flew at night. Encountered cumulonimbuses. Loss of control
A99P0105	Visibility at the site was about 75'. Aircraft was operated in IMC. Wilful violation.
A00O0082	Departed at 0311 EDT. Dark night. Overcast and below VFR minimum visibility. Airspeed below Vmini at impact.
A01Q0118	Pilot flew a short distance and hit trees 30' above ground. Witnesses report thick fog at the time. Likely wilful violation.
A04C0051	Cross-country flight Regina to Swift Current. Encountered IMC Continued. Controlled flight into terrain 3.8 miles short of destination. Wilful violation
A07O0238	Continued flight in darkness and IMC. Violation
A15C0130	Conducted flight into deteriorating weather conditions and darkness. Wilful violation.

Twenty-two accidents were due to rotor-induced whiteout while manoeuvring over snow at low altitude and low airspeed, most happened during approach and landing. At such low speeds, the pitot-static instruments would not function accurately and would, therefore, not provide the pilot with useful information to control the aircraft. Even if some useful information

was made available, it is unlikely that the pilot would be able to transition from visual references to instruments in time to prevent the accident. To illustrate the difficulty of these conditions, the aircraft in occurrence A13C0182 was fully instrumented, and the flight crew held current instrument ratings.

Table 2. Loss of visual references in rotor-induced whiteout (snowball)

Occurrence Number	Summary
A93P0003	B 212. Heli-skiing. Reduced visibility. Maintained heading & reduced speed. Landed and rolled
A94P0029	Vertical takeoff to hover. Moved over a gully & aircraft descended. Then visibility reduced to 0. Struck trees.
A91W0046	Landing on frozen lake. Aircraft rolled over.
A96Q0203	Landing in confined area. Downwash blew snow up reducing visibility. Tail rotor strike
A97P0207	Landing on snow. Lost visual references, struck trees.
A98P0054	Landing. At 10' lost visual references in rotor-induced whiteout.
A99P0030	Heli-skiing. Lost visual references in rotor-induced whiteout.
A01W0102	Slinging. Picking up load from frozen lake. Lost all visual references. Loss of control
A03C0109	Cross-country flight. Snow squall. Elected to land on gravel clearing. On approach, rotor induced whiteout. Dynamic roll-over.
A03Q0189	Landing. Whiteout. Aircraft drifted. Main rotor strike.
A04P0395	Lost visual references in snow & blowing snow. Attempted to land. Hard landing. Substantial damage.
A05Q0008	Landing. Whiteout conditions. Conducted vertical descent. A skid dug in. Aircraft rolled. Main rotor strike.
A05P0044	Heli-skiing. In approach to pick up skiers, lost visusal references, but still seeing skiers, continued toward them. Tail rotor strike.
A09P0060	Avalanche control. Wind gust & downwash created whiteout and blew aircraft into the slope.
A10P0004	Heli-skiing. On approach, whiteout.
A10P0073	Heli-skiing. Whiteout on landing.
A13C0182	Whiteout in landing on snow. IFR aircraft and crew.
A14W0105	On short final visual contact lost. Aircraft hovered, drifted and main rotor struck a tree.
A15P0049	Downhill & downwind takeoff. Aircraft started to settle, encountered whiteout (snowball). Main rotor struck tree.
A16P0223	Heli-skiing. Landed at unprepared site. Rotor-induced whiteout. Skid dug in. Aircraft rolled.
A11C0038	Operating at 150' following survey line. Encountered whiteout & lost visual reference to Frozen lake.

A16Q0166	Flying slow (5 mph.) and low (1'). Raised snow. Lost visual references. Main rotor strike on a tree.

Some light conditions, while not obscuring vision, like fog or blowing snow, make flying by visual references very challenging. Haze or uniformly coloured terrain against a white atmospheric background can make it very difficult to maintain a constant height. A smooth water surface, termed glassy water, can make it impossible to perceive height above the water. Such challenging conditions can be insidious. Visibility may be excellent so pilots may have no cues to alert them that conditions are conducive to collision with terrain or LOC. At night pilots are subject [to] "Black hole illusion", which leads them to believe their aircraft is higher than it is.

The following 25 accidents occurred in such challenging light conditions. The difficulty of flying in such conditions is illustrated by the fact two fully instrumented helicopters with instrument rated crews flew their machines into the ground (A08O0029, A13H0001). Basic instrument skills and augmented instruments would not likely have prevented these accidents.

Table 3. Challenging light conditions

Occurrence Number	Summary
A03O0344	Aerial survey. Turning. Glanced at radio altimeter. Watched GPS in the turn. Manoeuvring struck frozen lake surface.
A88A0223	Helicopter took off after dark for a cross-country flight. Collided with high terrain.
A91A0062	Visibility deteriorated. Tried to turn around. Lost visual references. Struck ice.
A93A0060	B 206. Over ice at low level to observe seals. Whiteout. Struck surface.
A93W0019	Whiteout. Slowed to 40-45 mph. Skid dug in. Aircraft rolled.
A94C0015	Crossing frozen lake. Checked instruments. Lost visual reference and struck surface and rolled.
A95C0046	Overcast 300'. Visibility OK, > 8 mi. Encountered fog. Whiteout. Aircraft struck the ice surface
A96W0072	CFIT. Probable whiteout.
A96C0087	Aircraft struck ice at approx normal cruising speed and straight and level attitude
A97P0298	Visibility 2 mi in rain & fog. Glassy water. CFIT into water.
A98C0089	Takeoff. Transitioned from hover to forward flight. Aircraft descended and struck terrain. Overcast. Moderate snow
A01P0173	Glassy water. After takeoff, low rotor RPM warning. Aircraft struck water.
A04C0190	IFR flight. Despite being IFR, aircraft struck terrain shortly after takeoff in whiteout conditions.
A05P0262	Glassy water landing. Aircraft touched before pilot expected. Floats dug in. Aircraft rolled.
A02P0256	Terrace to Sandspit Island. Low clouds. Glassy water. CFIT

A07C0094	Cross-country flight. Ceiling and visibility OK at takeoff. Encountered whiteout. Struck ground at very low airspeed. No injuries
A08O0029	IFR rated crew. Instrumented aircraft. Landed short on dark night approach to heli-pad.
A08W0162	Departed over water. Vision possibly obscured by glare. Possible somatogravic illusion.
A08P0288	Flying over glacier. Flat light. Struck surface.
A09Q0111	Continued flight in adverse weather conditions and unfamiliar topography. Pilot considered self expert in low visibility flying.
A10Q0133	Undetermined. Aircraft struck surface of the sea in low ceilings. Likely VMC, but reduced visual references possible.
A13H0001	Ornge. Fully instrumented aircraft and IFR rated pilots. CFIT.
A10O0145	Continued flight in area of low ceiling and visibility. Did not obtain all the weather conditions for the route. Struck tower at very low height.
A13C0073	Likely IMC in smoke & rain. Lost orientation & struck lake surface. High speed impact indicates pilot believed he had VMC.
A13W0073	Deteriorating weather conditions. Diverted. Struck trees while manoeuvring at low airspeed.

The final group is a set of 12 accidents involving VFR flight into IMC. In each case, it is most likely that the aircraft was flying at a low airspeed, as evidenced in A01W0241, A06W0066, A10Q0148, and A12P0079. In these cases, the aircraft was operating below Vmini and the pitot static instruments were inaccurate. The transition from VFR to IFR control, even for a current instrument pilot, takes time, and it is unlikely that the transition could be made in time to maintain control of an inherently unstable aircraft.

Table 4. VFR into IMC

Occurrence Number	Summary
A97P0009	Loss of control. Probable low visibility in mountains. Airspeed estimated below Vmini at impact.
A97P0207	Loss of control in IMC. Low time pilot. Looking for landing pad, probably below Vmini.
A99A0127	Visibility ¾ to 1 mi. XC flight following a road at 500'. Entered fog. Lost visual references. Loss of control
A00C0099	XC flight. After takeoff at 400’ turned. Realized inadequate visual references. Began turn to regain visual references. Loss of control.
A01W0241	VFR flight. Ran into deteriorating weather conditions. Struck trees at 20'. No injuries.
A05A0155	Encountered heavy snow shower and became disoriented, reduced airspeed to 60 knots. 30 knot winds.

A06W0066	Ferry flight. Encountered deteriorating weather conditions. Precautionary landing. Main rotor strike.
A10Q0132	Continued flight in marginal VFR, probably IMC. Struck rising ground at low airspeed -26 knots.
A10Q0148	Precautionary landing due rain & thunderstorms. On final lost visual references due to rain on windscreen.
A11P0025	Heli-skiing. Encountered marginal VMC. Tried to descend through break in cloud. Aircraft struck snow. Pilot uninjured. Below Vmini.
A11W0152	Continued flight in IMC. Went above cloud and had to descend through cloud. Did not request assistance from ATS.
A12P0079	Likely encountered IMC. Lost spatial orientation. Ground speed 45 knots.

Conclusion

This review of 465 accidents did not find a single accident that would likely have been prevented by having a complete set of instruments installed and acquisition of basic instrument flying skills by VFR pilots. The challenge is illustrated by the fact that the accident record includes fully instrumented helicopters with instrument rated crews who were unable to maintain control in challenging conditions. TC believes that adoption of this and its associated recommendations would not enhance light helicopter safety.

Since implementation of Recommendations A90-84, A90-81 and A90-83 are unlikely to enhance helicopter safety, TC does not agree with them and will provide no further updates on them.

March 2024: TSB assessment of the response (Unsatisfactory)

Transport Canada (TC)'s response addresses the following three recommendations made in TSB's Aviation Safety Study 90-SP002:

> 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 Recommendation A90-81**
>
> The Department of Transport require all helicopters engaged in commercial passenger carrying operations be equipped with radar altimeters.
>
> **TSB Recommendation A90-83**
>
> The Department of Transport require all commercially-operated helicopters to be equipped with appropriate instrumentation for the conduct of basic instrument flying.
>
> **TSB Recommendation A90-84**

In its last formal response in 2017, TC stated that it did not agree with these recommendations and reiterated that the most effective means of mitigating the underlying safety deficiencies was to avoid flying helicopters into adverse weather conditions when operating under visual

flight rules. TC's response was mainly grounded on the conclusions of its analysis of 465 helicopter accidents that occurred between 1988 and 2016, which TC believed would not have been prevented by recommendations A90-81, A90-83, and A90-84.

The TSB disagrees with TC's assessment. There continues to be occurrences involving commercial helicopters flying into inadvertent instrument meteorological conditions. The TSB has identified loss of spatial awareness in 13 investigations involving commercial helicopter flights conducted between 2010 and 2018.

One such occurrence is the Airbus Helicopters AS 350 B2 accident in Griffith Island, Nunavut, on 25 April 2021 (A21C0038), which led to the issuance of four recommendations, three of which are directed towards commercial helicopter operations. These are as follows:

> The Department of Transport require commercial helicopter operators to ensure pilots possess the skills necessary to recover from inadvertent flight into instrument meteorological conditions.
>
> **TSB Recommendation A24-01**
>
> The Department of Transport require commercial helicopter operators to implement technology that will assist pilots with the avoidance of, and recovery from, inadvertent flight into instrument meteorological conditions.
>
> **TSB Recommendation A24-02**
>
> The Department of Transport enhance the requirements for helicopter operators that conduct reduced-visibility operations in uncontrolled airspace to ensure that pilots have an acceptable level of protection against inadvertent flight into instrument meteorological conditions accidents.
>
> **TSB Recommendation A24-04**

Despite recommendations A90-81, A90-83, and A90-84 being issued over three decades ago, TC has yet to implement adequate measures to address the safety deficiencies outlined therein. The recent occurrences involving commercial helicopters flying into instrument meteorological conditions underscore the ongoing relevance and urgency of these recommendations.

Therefore, the responses to recommendations A90-81, A90-83, and A90-84 are assessed as **Unsatisfactory**.

File status

TC has indicated that no further action will be taken to address these recommendations, yet the safety deficiencies have not been sufficiently mitigated, and the safety risks associated with commercial helicopter operations persist. These safety issues are articulated in more recent recommendations (A24-01, A24-02, and A24-04), which supersede recommendations A90-81, A90-83, and A90-84. The TSB urges TC to swiftly implement safety measures in response to these new recommendations and will be closely monitoring its actions and progress to mitigate the safety deficiencies identified in the new recommendations.

The Board will reconsider the status of this deficiency file once TC has provided its initial response to these three most recent recommendations.

This deficiency file is **Dormant**.