ASSESSMENT OF RESPONSE TO
AVIATION SAFETY RECOMMENDATION A90-83

RADAR ALTIMETERS

Background

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.

Board Recommendation A90-83 (13 November 1990)

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 recommends that:

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

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

Transport Canada's Response to A90-83 (21 March 1991)

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

Development of Board Assessment of TC Responses to A90-83 (11 May 2005)

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**.

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.]
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> 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

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

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.

Board Review of A90-83 Deficiency File Status (01 October 2010)

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.

A90-83 Deficiency Analysis Update (12 October 2011)

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 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**.

Next TSB Action (12 October 2011)

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

Transport Canada Letter - A90-83 (07 December 2011)

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.*
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> *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.

Transport Canada Letter - A90-83 (07 May 2012)

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.

Board Assessment of Response to A90-83 (05 September 2012)

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**.

Next TSB Action (05 September 2012)

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.