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Different Altimeter Displays and Crew Fatigue Likely Contributed to Canadian Controlled-flight-into-terrain Accident

The official Canadian accident report said that the nonflying pilot's altimeter, course track indicator and heading settings had not been set accurately to enable accurate monitoring of the nonprecision night approach.

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Editorial Staff Report

The crew of the twin-turboprop Swearingen SA26T Merlin II was executing a localizer back course approach at night to Thompson Airport, Manitoba, Canada. While proceeding inbound on the localizer, the crew allowed the aircraft to descend below the published minimum crossing altitude. The aircraft, on a medical evacuation (MEDEVAC) mission, collided with a nondirectional beacon (NDB) transmitter antenna and crashed 3.4 miles (5.5 kilometers) northeast of the airport. Instrument meteorological conditions (IMC) prevailed. Both flight crew members were killed, and the flight nurse was seriously injured in the June 1, 1994, accident.

The Transportation Safety Board (TSB) of Canada concluded in its final accident report that the causes of the accident were: "The flight crew lost altitude awareness during the localizer back course approach, and allowed the aircraft to descend below a mandatory level-off altitude. Contributing factors to this occurrence were the crew's deviation from a published approach procedure, ineffective in-flight monitoring of the approach, rapidly developing localized fog conditions and, probably, pilot fatigue."

The Merlin II was owned and operated by Keewatin Air Limited, which provides aeromedical transport services, the report said. The crew of the accident flight had just completed a MEDEVAC flight from Coral Harbour, Northwest Territories (NWT), to Churchill, Manitoba. "At 2257 central daylight saving time (CDT), the aircraft departed Churchill for a night, instrument flight rules (IFR) flight to return to the aircraft's base of operations at Thompson, Manitoba," the report said. "The en route portion of the return leg was conducted at an altitude of 18,000 feet [5,490 meters] above sea level (ASL)."

The first officer was the pilot flying (PF), and was in the left seat, the report said. The captain, the pilot not flying (PNF) was in the right seat, and handled all radio communications during the flight. "At 2349 CDT, the captain reported that the aircraft was 42 miles [68 kilometers] northeast of Thompson and requested a descent clearance," the report said. "The aircraft was initially cleared down to 7,000 feet [2,135 meters] ASL. Several minutes later, the crew was given a clearance for an approach to the Thompson Airport, with a restriction to remain on the 30-degree radial of the Thompson VOR [very high frequency omnidirectional radio range] until below 3,000 feet [915 meters] ASL," the report said.

The crew reported descending through 3,000 feet, and gave a position report of 12.3 miles (20 kilometers) from the

Thompson VOR, the report said. At this point, the flight was told to contact the Thompson flight service station (FSS) for in-flight monitoring. The crew contacted Thompson FSS at approximately 2358. "The crew indicated that they were planning to complete a localizer back course approach to Runway 23, they already had their approach clearance and they would call once established on the final approach," the report said.

The localizer back course approach incorporates an 11-mile (17.7-kilometer) arc to intercept the localizer, the report said. Once established inbound on the localizer, an aircraft can descend to 1,500 feet (457 meters) until crossing the Hotel NDB, the final approach fix (FAF). After crossing the FAF, an aircraft can descend to the minimum descent altitude (MDA) of 1,080 feet (329 meters) ASL, the report said. The airport elevation is 729 feet (222 meters) ASL.

Aircraft Collided with Tower

The FSS operator provided the flight with the latest weather observation, and asked the crew for a pilot report (PIREP) on the cloud bases, the report said. Shortly thereafter, the aircraft collided with the Hotel NDB.

The report described the crash sequence: "The aircraft struck the Hotel NDB tower in a wings-level attitude at 62 feet [19 meters] above the ground. Approximately five feet [1.5 meters] of the right wing was severed from the outboard edge, and was recovered at the base of the tower. The right propeller severed one of the tower support cables, and the tower was knocked off its base. The aircraft continued forward and struck [a second antenna tower], knocking the top off the [tower] and ripping up several buried cables that were attached to the tower."

"After colliding with the two towers, the aircraft began a roll to the left, and descended steeply through the trees on a track of 230 degrees magnetic."

The report continued: "After colliding with the two towers, the aircraft began a roll to the left, and descended steeply through the trees on a track of 230 degrees magnetic. The aircraft hit the ground in a steep nose-down, left-wing-low attitude approximately 450 feet [137 meters] from the initial impact point with the tower. Once ground contact was made, the aircraft sliced through approximately 150 feet [46 meters] of dense trees before coming to a stop."

The report noted: "During the crash, the landing gear was torn off and the main wing structure was broken into four separate segments. The fuselage separated from the wing section and hit a 12-inch [30-centimeter] diameter jack pine. That collision split the fuselage, and resulted in two separate wreckage throw patterns; the flight nurse and components from the main cabin were thrown straight forward through a gaping hole in the front of the fuselage. The cockpit section was destroyed by the collisions with the ground and trees."

When the flight did not land, "the FSS operator initiated a communications search and ramp check, but the aircraft's location could not be verified," the report said. One minute after midnight, the Hotel NDB stopped transmitting and a technician was sent to troubleshoot the problem. "Approximately two hours and 40 minutes after the occurrence, the technician arrived at the site, and observed aircraft wreckage in the vicinity of the NDB tower," the report said. "This discovery provided the initial confirmation that a crash had occurred. The sole survivor [the flight nurse] was located approximately 20 minutes later."

The aircraft was destroyed by ground impact forces, the report said. There were no in-flight or postcrash fires.

The results of toxicological tests on the flight crew were negative, the report said, and there was no evidence of flight crew incapacitation.

When investigators examined the wreckage, they found that neither pilot seat had a shoulder harness installed, and the existing regulations at the time of the accident did not require shoulder harnesses to be installed, the report said.

When the aircraft cabin was examined, "two of the forward-facing cabin seats had been modified to accommodate the loading of stretcher patients," the report said. "The seat back and seat-belt attachment hardware had been replaced with quick-release pins to allow for the easy removal of the seat back. An examination of both forward-facing seats revealed that the quick-release pins had jarred loose during the impact sequence, releasing both sets of these cabin seat belts from their respective seats," the report said.

Investigators interviewed the flight nurse to determine where he was seated during the crash. The nurse had no memory of the accident, "but believes that he would have been sitting in the front forward-facing seat with his seat belt attached at the time of the accident," the report said. "Neither of the two forward-facing seat-belt buckles were fastened when examined. An examination of the wreckage could not confirm where the flight nurse had been sitting, [or] whether his seat-belt buckle had been attached at the time of the accident," the report said.

No Preimpact Systems Failures Found

Investigators examined the aircraft systems at the accident site, "and no preimpact structural failures or flight control system discontinuities were found," the report said. "It was determined

that, at the time of the crash, the landing gear was down, the flaps were up and the elevator was trimmed slightly nose-down, consistent with a descent profile. The aircraft checklist was found opened to the normal descent check page, indicating that the crew was performing their routine checks," the report said.

An examination of the cockpit instrument panel found that "the correct ILS [instrument landing system] frequency and the appropriate course for the published approach were set into the aircraft's navigational information display instrument used by the left-seat pilot," the report said. "The left-side altimeter was also accurately set. The right-side navigational equipment was tuned to the appropriate ILS frequency, but the course setting, the heading selector bug and the right-side altimeter were not accurately set to monitor the approach," the report said.

The accident aircraft was equipped with a global positioning system (GPS) receiver, which was not approved as a sole means of navigation, the report said. Data recovered from the GPS receiver after the accident indicated that "the selected GPS waypoint was the Thompson VOR; at some point during the flight, the crew had been navigating direct to that location; and, the last indicated time and date was 00:01:33.8 CDT, June 1, 1994," the report said.

Investigators reviewed the accident aircraft's maintenance records, the weight and balance for the accident flight and the aircraft's installed equipment. All the required inspections had been performed at the time of the accident flight, and there were no outstanding discrepancies, the report said. The weight and balance for the accident flight were within limits.

"The altitude alerting system [in the accident aircraft] was found to be set to 5,400 feet [1,647 meters] … "

The accident aircraft was not equipped with, nor was it required to have, a cockpit voice recorder (CVR), a flight data recorder (FDR) or a ground-proximity warning system (GPWS).

The cabin of the accident aircraft was configured for MEDEVAC operations. "The interior had been modified to incorporate essential medical equipment along with seating and stretcher locations for a flight nurse, several patients and patient escorts," the report said.

Nearly Inaudible Horn Sounded by Altitude Alerter

The aircraft was equipped with an altitude alerting system, "which provides both aural and visual warnings to the pilot when the aircraft enters an altitude that is 300 feet [91.5 meters] above or below any preselected altitude," the report said. "The normal procedure, as outlined in the company Flight Operations Manual and aircraft checklist, is to use this altitude alerting system during the climb, en route and en route–descent portions of a flight. During the final approach phase of flight, crews rely on their own monitoring of the altimeter display information as part of their normal instrument scanning or cross-check, as well as on the information and warning provided by the radar altimeter system," the report said.

"The altitude alerting system [in the accident aircraft] was found to be set to 5,400 feet [1,647 meters] … ," the report said.

Also installed in the cockpit was a King (KRA 405) radar altimeter system, "which is normally used for the final approach portion of the flight, and is not usable at altitudes above 2,000 feet [610 meters] AGL," the report said. "The system will generate both visual and audio warnings when the aircraft descends to, or is below, the preset value. These warnings can be canceled out by pilot selection."

Both the visual and aural warning on the accident aircraft's radar altimeter system were installed on the lower instrument panel, in the vicinity of the left-seat pilot's right knee, the report said. The aural warning system consisted of a horn that emitted a high-frequency, pulsating sound at an 80-decibel (dB) level. "The aural warning horn (sonalert) was properly wired, and was tested to be serviceable after the accident," the report said. "The audio output signal from the radar altimeter could not be selected by the flight crew for use over the aircraft's speaker or headphone system."

During the investigation, the radar altimeter in the accident aircraft "was found to be serviceable and set to the MDA for the approach," the report said. "Testing and evaluation of the sonalert horn indicated that the 80 dB warning could be attenuated to as low as a range of 31 dB–37 dB by the time it reached the pilots' ears if headsets were being used. This level of sound would be barely audible above the ambient noise of the cockpit," the report said.

The aircraft was also equipped with an intercom system, which did not incorporate a "hot" microphone feature to permit continuous intercockpit communications, the report said. "To communicate using the intercom system, one of the crew members was required to select a panel-mounted rotary selector switch to the PA position, and then depress a transmit button which is located on either control column," the report said. "Standard practice within the company was to select the PA position, and have the [PF] depress and hold down the transmit button during the final approach phase of the flight. Some pilots were known to position an elastic band around the control column in order to hold the transmit button in its activated position," the report said.

The qualifications of both pilots were reviewed. The captain, age 50, held a Canadian airline transport license (ATPL) and a valid medical certificate. He had more than 20,000 total flying hours, with 3,160 hours in the Merlin II, the report said.

The captain had been employed by Keewatin Air Limited for $2^1/_2$ years, and had been recently promoted to assistant chief pilot, the report said. Most of his flying experience was in the remote regions of Northern Ontario, Manitoba and the NWT. "Two months prior to the accident, the captain had been reassigned from the Rankin Inlet, NWT, base to the Thompson Base," the report said.

The first officer, age 29, held a Canadian ATPL and a valid medical certificate, and was certified to serve as first officer on the Merlin II, the report said. He had 3,700 total flying hours, and 375 hours in the Merlin II. "Records indicate that he had only three hours of experience flying from the left seat of the Merlin aircraft," the report said. "The first officer was tentatively scheduled to be upgraded to relief captain on the Merlin II aircraft in June 1994."

The first officer was also qualified as a captain on the Piper Navajo, Piper Seneca, Britten Norman Islander and Beechcraft Baron, the report said.

Investigators reviewed the activities of the flight crew before the accident. "The captain had just returned from five days off, and was conducting his first MEDEVAC flight since his return to duty," the report said. "He reportedly had good sleep habits, and had received adequate rest the previous night. He began his scheduled stand-by duties at 0800 CDT on the day of the accident, and his crew duty day would have begun at approximately 1430 CDT, the initial time of dispatch for this MEDEVAC flight. The captain's total flight time the day of the accident was approximately 6.4 hours," the report said.

Stress Added to 17 Hours of Wakefulness

When the first officer's activities were reviewed, investigators found that he "had been holding various stand-by and flying duties over the two-week period leading up to the accident," the report said. "Over that period, he had been on stand-by for a total of 180 hours, had flown on nine of those 14 days, and had completed 19 separate flight legs and 40.3 flight hours. Several days prior to the accident, the first officer is known to have been awake for a minimum of 36 continuous hours," the report said.

The first officer, as the result of stress from the ongoing stand-by/duty commitments with Keewatin Air Limited, had been actively seeking employment with another air carrier that provided scheduled passenger service, the report said. "Several days prior to the accident, the first officer received news that his bid for employment with another air carrier had failed," the report said. "This news precipitated a period of discouragement, irritation and increased anxiety. This mood shift was out of character, and was noted by his friends to extend throughout the period leading up to the accident."

The report noted: "On the day of the accident, the first officer began his stand-by responsibilities at 0800 CDT, and was scheduled to remain on call for a 12-hour period. He awakened at approximately 0700 CDT, completed an aircrew medical in the early afternoon, and was recalled for the MEDEVAC flight at approximately 1430. His crew duty day began with that recall and, at the time of the accident, he had accumulated $9^1/_2$ hours of duty time, and had been awake for approximately 17 hours."

In its analysis, the TSB concluded that the stress experienced by the first officer "would likely have caused some additional fatigue," the report said. The TSB also concluded that the captain had probably been awake the same number of hours as the first officer. "By the time of the accident, the combination of circadian rhythms, hours awake and workload had likely placed both pilots in a fatigued state. Seventeen hours of wakefulness alone would lead to some level of fatigue-induced performance decrement," the report said.

The first officer, as the result of stress from the ongoing stand-by/duty commitments with Keewatin Air Limited, had been actively seeking employment with another air carrier.

The operations of Keewatin Air Limited were reviewed. The company "maintains a stand-by and dispatch system that allows crews to become airborne within 45 minutes of receiving a MEDEVAC request," the report said. "This dispatch system requires flight crews to carry pagers, and to meet stand-by duty commitments on an ongoing basis."

The report said that "some crews who have been involved in MEDEVAC operations have expressed concerns about their continuing requirements to hold lengthy stand-by commitments, and their capacity to commence a full and effective duty day at any time within those stand-by periods."

Crew Ignored Published Procedure

Investigators attempted to review the descent profile flown by the accident flight crew. This was hampered by the fact that the entire flight was outside the area of air traffic control (ATC) radar coverage, and therefore no altitude or position information regarding the accident flight was available, the report said. Investigators used a combination of company

operating procedures and the reports made by the flight crew to ATC to evaluate the descent and approach.

The report said: "The en route descent profile normally flown by the company pilots for the Merlin II is just under the aircraft's maximum operating speed. This profile reduces the en route time and minimizes throttle adjustments during the descent. The Merlin crews use a simple rule of thumb to determine the initiation point for a descent and to confirm that the aircraft is remaining on a normal descent profile. A review of the ATC tapes indicates that the crew requested a descent from 18,000 feet ASL when the aircraft was 42 nautical miles (nm) [78 kilometers] northeast of Thompson.

"Application of the rule of thumb would have required descent initiation at 41 nm [76 kilometers]. Similarly, when the crew reported 12.3 nm [23 kilometers] from the airport, the aircraft was on a normal descent profile. By using this descent profile, the majority of the cockpit workload related to the aircraft's level-off, deceleration, before-landing checks and reconfiguration for final approach is completed within a five-mile [eight-kilometer] segment short of the destination aerodrome."

Investigators calculated the times and distances traveled by the accident aircraft during the descent, and determined that "the aircraft's average ground speed was 214 knots, and that its vertical speed was approximately 1,900 feet per minute (FPM) [579 meters per minute] for the period of the descent from 18,000 feet ASL to the last reported altitude of 3,000 feet ASL," the report said. "These computed values were used to extrapolate the point at which the aircraft would reach its initial level-off altitude. Based on that calculation, the aircraft should have been leveling off approximately 11 miles [17.7 kilometers] from the Thompson VOR, or nine miles [14.5 kilometers] to the northeast of the Hotel NDB tower."

The report concluded: "Based on a review of the elapsed time between the crew's receipt of the approach clearance and the aircraft's collision with the tower, the aircraft could not have followed the published procedure, but rather must have followed a more direct route to the final approach fix, the Hotel NDB. The minimum sector altitude for this area is published as 2,400 feet [732 meters] ASL."

Investigators reviewed the company's Flight Operations Manual, which required the PNF to monitor "all regimes including altitude, attitude, airspeed, heading, navigation and final approach/glidepath position both during VFR and IFR flight," the report said. "If the [PF] does not respond to a second warning to correct a deviation, the PNF is authorized to take control of the aircraft."

Regarding altitude awareness and mandatory calls, "the PNF is to ensure the correct preselection of the altitude alerting system, and is to call out the aircraft's indicated altitude when it is 100 feet [30.5 meters] above any pertinent minimum altitude during an instrument approach," the report said. "The radar altimeter is normally included in the pilot's instrument scan pattern when the aircraft is established on final approach beyond the final approach fix/beacon."

The report said: "Examination of the wreckage revealed that the PNF's altimeter, course track indicator and heading settings had not been accurately set to enable accurate monitoring of a localizer back course approach to Runway 23."

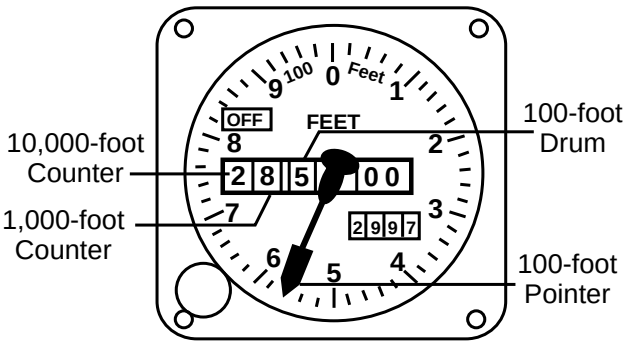
The TSB was unable to determine why the crew descended below the minimum crossing altitude for the NDB. The report speculated that "one possibility is that the crew may have been distracted by some unknown malfunction, or by some other cockpit activity, and that they did not notice the altitude deviation. The crew's deviation from the published approach routing added additional workload, and further compressed the workload into a shorter time span between localizer interception and beacon crossing."

Based on their calculations, investigators concluded that the crew might not have intercepted the localizer until they were close to the NDB, the report said.

Dissimilar Altimeters Likely Caused Confusion

The cockpit of the accident aircraft was equipped with two different altimeter displays, the report said. The altimeter on the left side of the instrument panel was a counter-drum/pointer display (Figure 1), but the altimeter on the right side of the instrument panel was a three-needle display (Figure 2, page 6), the report said. The three-needle display altimeter was used in the company's Piper Navajo.

Counter-drum/Pointer Display Altimeter

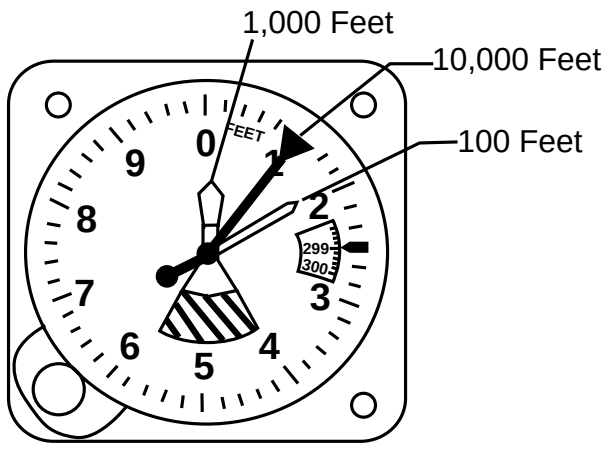


Source: Transportation Safety Board of Canada

Figure 1

The report noted: "Without adequate monitoring by both crew members, there would have been an increased risk that the PF might misread the altimeter. This risk would have been elevated

Three-needle Display Altimeter



Source:Transportation Safety Board of Canada

Figure 2

because of his previous experience using needle-type displays, and because he would have been accustomed to monitoring the needle, rather than the drum portion, of the altimeter presentation."

The TSB believed that the crew's failure to adhere to the published instrument approach procedure "is consistent with what would be expected of a fatigued flight crew," the report said. "The PNF's failure to reset the right-hand navigational instruments and altimeter, and accurately monitor the approach are also examples of behavior expected of a fatigued pilot. Fatigue was probably an insidious contributor to this accident," the report said.

The weather on the night of the accident flight was reviewed. "The Thompson terminal forecast ... valid for the period near midnight ... predicted an 800-foot [244-meter] AGL broken ceiling and six miles [9.6 kilometers] visibility, with conditions lowering to a thin obscured, overcast ceiling at 800 feet AGL, and two miles [3.2 kilometers] visibility for occasional periods," the report said.

The Thompson weather observation, taken at midnight, was: 1,200 feet (366 meters) broken, 8,000 feet (2,440 meters) broken, visibility 15 miles (24 kilometers), temperature 11 degrees C (51 degrees F), dewpoint 10 degrees C (50 degrees F). No fog was reported, the report said.

In its analysis, the TSB concluded that, based on the forecast and hourly reports, "the crew would have been expecting to break out below the cloud base at approximately 1,900 feet ASL," the report said. "Under those conditions, it would be reasonable for the crew to anticipate that they would be clear of the cloud when at 1,500 feet ASL, the beacon crossing altitude, and that they would be able to fly the final approach under visual conditions."

But the report said a special weather report was issued about 30 minutes after midnight "to indicate that the visibility had decreased to four miles [6.4 kilometers] in fog at the Thompson Airport. … The crew of an aircraft that departed Thompson approximately 45 minutes after the accident reported to the Thompson [FSS] that they lost visual contact with the ground at approximately 200 feet [61 meters] AGL. The visibility during their takeoff roll was reported to be one-half mile in fog, and the top of the fog layer was estimated to be approximately 500 feet [152 meters] AGL at that time."

When the accident aircraft descended during the approach, "it would have entered the fog bank, placing the aircraft in [IMC]," the report said. "It is possible that the expectation of flying into visual [meteorological] conditions may have influenced the crew to relax their normal cockpit monitoring functions, as evidenced by the captain not setting his instruments for the localizer back course approach. Additionally, the fact that the aircraft remained under IMC throughout the final portion of their descent may have reinforced a false perception that they were still above the reported 1,900 feet ASL ceiling," the report said.

As a result of the investigation, the TSB developed the following major findings:

- "The flight crew was certified and qualified for the flight in accordance with company procedures and Transport Canada regulations;
- "The aircraft was certified, equipped and maintained in accordance with existing regulations and approved procedures;
- "There was no evidence found of any airframe failure, flight control failure or systems malfunction prior to or during the flight;
- "The aircraft likely entered a rapidly developing low-level fog bank at some point prior to hitting the NDB tower;
- "It is likely that the crew [was] not aware of rapidly developing fog conditions, and may have been expecting to be in visual conditions at the beacon crossing altitude of 1,500 feet ASL;
- "The crew did not fly the published approach routing, but followed a more direct route to the final approach fix;
- "During the descent to the beacon crossing altitude, it is likely that the PF misread the altimeter; the probability for this error would have been increased because of differences in the left-seat and right-seat altimeter displays, and because of the PF's previous experience with other display types;

- "The radar altimeter and the associated warning light were mounted behind the pilot's control column, and outside the area of the pilot's normal instrument scan;

- "The audio output signal from the radar altimeter could not be selected by the flight crew for use over the aircraft's speaker or headphone system;

- "The sound emitted by the radar altimeter's aural warning horn would have been barely audible to the pilots above the ambient noise of the cockpit, unless the transmit button had been depressed while the horn was sounding;

- "The brightness of the altitude alerter visual warning display at night can be distracting to the flight crew;

- "Pilot fatigue and personal stress likely adversely affected the performance of the PF;

- "It is likely that the PNF did not adequately monitor the approach in accordance with the Flight Operations Manual; [and,]

- "The cabin seat-belt restraint system had been modified, and it failed during the crash sequence."

The report said that the following action was taken by Keewatin Air Limited as a result of this accident: "The chief pilot has taken steps to ensure that all standard procedures are adhered to. Also, a designated flight examiner was retained to act as an independent auditor of ongoing training, reporting any concerns directly to the chief pilot and the operations manager."

As a result of the fatigue issues in this accident, the Canadian Aviation Regulation Advisory Council (CARAC) proposed regulations to address the following issues:

- "Flight Duty Time — Definition: 'Flight duty time' will start when the pilot reports for flight duty, is on stand-by with a reporting time of one hour or less or reports for any duty assigned by the air carrier prior to flight duty;

- "Flight Duty Time — Extensions: Extensions will be limited to unforeseeable operational circumstances and be permitted only if no reasonable alternative is available. The extension is limited to a maximum of three hours, and the subsequent rest period will be extended by an amount equal to the flight duty time extension;

- "Flight Duty Time — Positioning: Positioning flights (nonrevenue) will now contribute towards maximum flight and duty times;

- "Predictable and Protected Rest Periods: When a pilot is on reserve or stand-by with more than one hour reporting time, the air carrier will be required to either provide the pilot with a daily predictable and protected rest period, or apply more restrictive flight duty times and/or extended rest periods."

The report noted: "If implemented, these proposed revisions should help aircrew to plan rest periods, eliminate the long periods of on-call or duty time and provide for reasonable amounts of scheduled stand-by time. In addition, Transport Canada intends to publish an Air Carrier Advisory Circular concerning fatigue and fatigue countermeasures."

In its report, the TSB noted that, during an 11-year period, "70 commercially operated aircraft not conducting low-level special operations were involved in CFIT [controlled-flight-into-terrain] accidents in Canada," the report said. "In view of the frequency and severity of such accidents, the Board is conducting a study of CFIT accidents to identify systemic deficiencies. The study will include, *inter alia*, an examination of CFIT data involving aircraft altimeter displays, altitude alerting systems, radar altimeter systems, use of [GPWS] and MEDEVAC flights."

The TSB expressed concern that "a disproportionately high number of CFIT accidents have involved MEDEVAC flights," the report said. "The Board is concerned that current operating procedures and practices may be contributing to many of these MEDEVAC accidents. Therefore, the TSB is further analyzing recent MEDEVAC occurrence data to identify any underlying systemic deficiencies."

The TSB also expressed concern about several accidents that had occurred because the flight crews did not hear audio warnings from the various cockpit alerting systems. As a result, the TSB recommended that "the Department of Transport advocate the provision of audio warnings which can be heard by pilots through whichever audio system they have selected for use," the report said.♦

Editorial note: This article was adapted from *Controlled Flight into Obstacle and Terrain, Keewatin Air Limited, Swearingen Merlin II, C-FFYC, Thompson, Manitoba, June 1, 1994*. Report no. A94C0088, prepared by the Transportation Safety Board (TSB) of Canada. The 32-page report includes appendices and illustrations.

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