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Commuter Crew's Loss of Situational Awareness During Night Takeoff Results in Controlled Flight into Terrain

An inspection of the operator by Canada's Transportation Safety Board, after the accident, resulted in the removal of the company's maintenance certificate and suspension of its operating certificate, the official report said.

Editorial Staff Report

The twin-turboprop Hawker Siddeley HS 748 departed Sandy Lake Airport, Ontario, Canada, on an instrument flight rules (IFR) flight plan at night. After takeoff, the aircraft turned approximately 120 degrees, descended into trees and crashed. The crew of a search aircraft that departed 15 minutes after the accident said that the ceiling was 700 feet (213 meters) above ground level (AGL), and that light snow was falling. All four passengers and three crew members were killed in the Nov. 10, 1993, accident.

The Transportation Safety Board (TSB) of Canada concluded in its final accident report that the causes of the accident were: "After takeoff, the crew most likely lost situational awareness and, as a result, did not detect the increasing deviation from their intended flight path. Contributing to the loss of situational awareness was the lack of AC [alternating current] power to some of the flight instruments; the reason for the lack of AC power could not be determined."

The investigation was hampered because neither the accident aircraft's flight data recorder (FDR) nor its cockpit voice recorder (CVR) operated during the accident flight.

The aircraft was owned and operated by Air Manitoba Ltd. The accident flight (operating as NAM 205/206) was a scheduled passenger flight from Winnipeg, Manitoba, that included stops at Sandy Lake, Ontario; St. Theresa Point, Manitoba; Island Lake, Manitoba; and a return to Winnipeg. NAM 205/206 departed Winnipeg at 1438 hours central standard time (CST). The flight proceeded uneventfully until arriving at Sandy Lake at 1549, where the crew was unable to land because of a low ceiling and poor visibility, the report said. The crew then diverted to St. Theresa Point (their next scheduled stop), and landed at 1630. While on the ground, 26 passengers boarded, and the aircraft was fueled. The flight departed at 1720 for Sandy Lake, where the crew made a successful approach and landing at 1745, the report said.

During the stop, both engines were shut down, but the aircraft was not serviced, the report said. Twenty-two passengers deplaned, and the flight departed at 1805 with the two pilots, a flight attendant and four passengers. After taking off from Runway 29, the aircraft entered a right turn. "Witnesses indicate that the aircraft appeared to fly at a lower than normal height throughout the turn," the report said. After turning approximately 120 degrees, the aircraft descended into trees and crashed, about one nautical mile (1.85 kilometers) northwest of the airport. The aircraft was destroyed by the impact with the trees and the ground, and a postcrash fire, the report said.

During the crash sequence, "the aircraft entered the trees at a right bank angle of approximately 50 degrees, which steepened to 80 degrees to 90 degrees before the aircraft struck the ground," the report said. "The descent angle was approximately 25 degrees when the aircraft entered the trees, and it did not change appreciably before the aircraft struck the ground.

When the aircraft first entered the trees, it "traveled through the trees for about 200 feet [61 meters], then struck the ground and traveled for another 400 feet [122 meters] before coming to rest," the report said. "The initial track through the trees was about 50 degrees magnetic (M), changing to about 60 degrees M for the last 500 feet [152 meters] through the trees and on the ground."

The report described the wreckage path: "The aircraft started to break up on initial contact with the trees, and the entire crash trail was strewn with wreckage. The fuselage, from the area of the wing trailing edge to the empennage, was relatively intact and was the furthest piece of wreckage from the initial tree strike."

Examination of the wreckage revealed that "there had been a small postcrash fire in the right engine nacelle area which caused little damage," the report said. A larger postcrash fire had occurred in the area of the left-wing engine nacelle, which resulted in some burning and melting of wing metal. "The fire did not spread more than a few feet in any direction, and it is believed the fire was of short duration," the report said. "Soot was found in the snow around the area, suggesting that this was a fast-burning, fuel-fed fire. The fires self-extinguished."

The Sandy Lake Airport did not have, nor was it required to have, emergency response services. Local community members observed the crash, and assisted other rescuers in searching for the crash site and survivors, the report said. Everyone on board the aircraft had died by the time rescuers arrived, the report said.

No evidence was found of a preimpact failure or malfunction in the flight control system.

Rescuers found that the captain and first officer had separated from their seats as a result of impact. "The lap belt anchor points in both flight deck crew seats had started to tear out in overload, suggesting that the seats were occupied and the lap belts [were secured] at impact," the report said. "Both flight deck crew seats were equipped with shoulder harnesses. Examination of the harnesses indicated that it was probable that the shoulder harnesses were not secured to the lap buckle at impact."

The flight attendant was found "in the rear section of the fuselage, held in his seat by the secured lap belt," the report said.

Autopsies and toxicological tests were conducted on the bodies of the captain and first officer. "There was no indication of any pre-existing conditions which could have affected their performance," the report said.

Investigators examined the wreckage to determine whether a system failure could have occurred on the accident aircraft. No evidence was found of a preimpact failure or malfunction in the flight control system, the report said. Evidence was found that the ailerons on the accident aircraft were set for a left roll at the time of impact, the report said.

The landing gear was found in the up-and-locked position, which was "evidence that the hydraulic system was operable when the aircraft took off," the report said.

Both engines were examined and found to have been developing power at impact, but "the power level could not be determined from examination of the engines," the report said. Both propellers were examined and found to be "developing significant and similar thrust at the time of impact," the report said. It was determined from the propeller blade angles at impact that the aircraft hit the ground at a true airspeed of 180 knots.

The accident aircraft's electrical system was examined. The primary electrical system of the aircraft was supplied at 28 volts direct current (DC) by two engine-driven generators. Investigators were able to determine, based on the aircraft's equipment that was powered at the time of the accident, that there was 28 volts DC power to the left, right and center busbars during the accident flight, the report said.

The accident aircraft was equipped with two inverters that supplied AC power on two separate electrical buses. "Either inverter is capable of supplying the total AC electrical power requirements of the aircraft," the report said. "Single voltmeter and frequency gauges display the output from one inverter at a time, whichever one is selected on the display."

The magnetic indicator on the No. 1 AC bus was found, and indicated that the No. 1 AC bus was powered at the time of the accident, the report said. Nevertheless, "there was no other evidence found that indicated the No. 1 AC bus was powered at any time after the aircraft shut down after landing at Sandy Lake," the report said.

The evidence found in the wreckage supporting the theory that the No. 1 AC bus was not powered included the fact that neither the FDR nor the CVR operated during the accident flight, the report said. "A functional analysis of both recorders revealed they were capable of recording at the time of the accident," the report said.

Investigators also determined that the gyrosync compass system (powered by the No. 1 AC bus) for both the captain and the first officer was not operating at the time of the accident. "The master indicator was found on approximately the same heading ... as the heading of the aircraft when it was parked in front of the terminal," the report said.

The report continued: "A directional gyro rotor assembly was found and it did not exhibit any rotational damage, and its

windings were not [burned]; and a compass face was found with the compass rose captured by impact damage on a heading of 280 degrees. Runway heading is 290 degrees, and it is believed that the compass was set to runway heading by one of the pilots before takeoff, a normal procedure."

The captain's attitude indicator was also powered by the No. 1 AC bus, the report said. If the instrument was not powered, a warning flag should have appeared on the instrument face. Investigators were unable to locate in the wreckage either the captain's or the first officer's attitude indicator, or any associated parts, the report said.

Investigators concluded that the No. 1 AC bus was not powered at the time of the accident, but "it could not be determined why the indicator would be showing ON if the bus was not powered," the report said.

The No. 2 inverter and its associated AC bus powered the horizon indicator, oil temperature and pressure gauges, fuel gauge and other instruments and controls on the right side of the cockpit, the report said. Lack of power from the No. 1 AC bus caused by failure of the inverter should not have affected these instruments. In addition, the transfer switch for the No. 1 inverter could have enabled the crew to power the No. 1 AC bus from the No. 2 inverter, assuming that they were aware of No. 1's failure and that No. 2 was operating.

Investigators could not determine the status of the No. 2 inverter or bus. An oil pressure gauge recovered from the wreckage had a mark on it that indicated that the gauge was showing oil pressure, and was therefore powered, at the time of impact. "As the oil pressure gauges are AC powered, and as there was no power coming from the No. 1 AC bus, the mark on the dial is an indication that the No. 2 AC bus was powered," the report said. "This is the only evidence found regarding the state of the No. 2 AC bus."

The uncertainty about the status of AC power supplies during the brief flight made it impossible to draw firm conclusions about their role in the accident, other than that "the aircraft did take off without power to, at least, the No. 1 AC bus ... ."

The report suggested two possible scenarios:

1. No. 1 AC bus was not powered. "The loss of power from the No. 1 AC bus could have been the result of a failure, or the No. 1 inverter could have been intentionally turned off sometime between shutdown and normal aircraft start and not turned on again." The report noted, though, that this would have caused a number of signals that would have alerted the pilots to the malfunction had they performed a normal preflight checklist. "Therefore," the report said, "the pilots either did not complete all elements of the required checks, or they accepted that they would be without the left instruments, the flight recorders and the right gyro compass during the flight."

2. Both AC buses were not powered. Had this been the case, there would have been even more indications because of warning lights and inoperative instruments. "The likelihood of the simultaneous failure of both inverter systems is remote," the report said, but investigators also considered the possibility that the crew turned off both inverters after shutdown at Sandy Lake and then forgot to restart them. The crew might have also decided to delay turning on the inverters until just before takeoff, perhaps to allow more recharging of the batteries. "However, the crew would then have had to take off, not having completed the required checks that would have reminded them that the AC buses were not powered, and unaware of the failure indications that would have been evident."

The report concluded that "it is *improbable* that the crew could have had an AC power failure ... and not become aware of any fail indications prior to taking off. It is *equally improbable* that this crew would have taken off with the knowledge that the AC system was not operating as required by MEL and by safe operating practices." [Italics are in report.]

Investigators also found that many modifications had been made to the accident aircraft's electrical system, but no accurate circuit diagrams were available, the report said. When the recovered electrical components and wiring were examined and compared with the electrical system documentation, numerous discrepancies were found. It was unlikely that the flight crew would have been aware of these discrepancies, the report said.

The accident aircraft was not equipped with a ground-proximity warning system (GPWS), although a GPWS had been installed in the aircraft in the past, the report said. If a GPWS had been installed at the time of the accident, in the accident aircraft, it would have been powered by the No. 1 AC bus. At the time of the accident, there was no regulatory requirement in Canada that large turboprop aircraft must be equipped with GPWS, the report said.

As a result of the electrical system discrepancies found in the accident aircraft, investigators conducted an extensive review of the Air Manitoba maintenance department. The director of maintenance (DOM) and the quality assurance manager (QAM) told investigators "that there were adequate spare parts, time and manpower to allow for proper maintenance and servicing of company aircraft," the report said.

When line maintenance personnel were interviewed, it was revealed that "they were often required to work well beyond their normal day to repair aircraft for the next morning's flight," the report said. "They also indicated that apprentice mechanics were regularly working unsupervised during weekend shifts. During subsequent interviews with the DOM and QAM, they indicated that, at the time of the accident, staffing levels were low, and that there were insufficient numbers of parts and time to allow timely aircraft repair."

Investigators reviewed the maintenance records for the accident aircraft. "The review showed that Air Manitoba maintenance practices were, in many cases, not in accordance with requirements as specified in Air Regulations and Air Navigation Orders that pertain to Air Manitoba's operations," the report said.

Some examples of the numerous maintenance irregularities that were cited in the report included:

- Maintenance manuals that did not accurately reflect the approved maintenance program;
- Serial numbers for calendar-limited or time-limited aircraft components on the time-between-overhaul (TBO) list did not always match the serial numbers of the components actually installed in the aircraft;
- Minimum equipment list (MEL) items had been incorrectly deferred or deferred without reference to the MEL;
- The CVR in the accident aircraft had only one channel capable of recording at the time of the accident;
- Drawings for the installation of the CVR and the FDR could not be located; and,
- Serviceable parts had been removed from one aircraft and installed on another aircraft within the fleet.

On the accident aircraft, investigators found that, "at the time of the crash, the No. 1 engine was 2.6 hours overdue for a hot section inspection," the report said. "There was no evidence found that this inspection was scheduled to be accomplished."

Interviews with company personnel also revealed that "it would not be uncommon for some captains to conduct a flight, or series of flights, with equipment unserviceabilities which, in their opinions, would not greatly affect the airworthiness of the aircraft yet would be in contradiction of the MEL," the report said.

The report noted: "In January 1994, in light of some telephone calls received from Air Manitoba personnel and the crash two months earlier, TC [Transport Canada] inspectors assessed that Air Manitoba's risk indicators had risen to an unacceptable level, and ordered a special inspection of the company. The inspection ... identified serious maintenance deficiencies which resulted in the suspension of Air Manitoba's Approved Maintenance Certificate and the subsequent suspension of their Operating Certificate. ... The company subsequently contracted its HS 748 maintenance to another carrier, and regained its operating certificate."

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The weight-and-balance forms for the accident aircraft were not found, the report said. Investigators calculated the weight and balance for the accident flight, and found that the takeoff weight and center-of-gravity were well within limits. Takeoff performance for the accident flight was also calculated, and found to be within limits for the runway conditions. The runway at Sandy Lake is gravel and, at the time of takeoff, the surface was very hard-packed snow and ice, and was smooth. The one runway, 11/29, is 3,500 feet (1,067 meters) long and 100 feet (31 meters) wide, the report said.

The qualifications of both pilots were reviewed. The captain, age 52, held a Canadian airline transport pilot license (ATPL) and a Group l instrument rating. He held a valid medical certificate, with a requirement to wear glasses. The captain had 16,000 total flying hours, with 4,500 hours in the HS 748, the report said.

The captain had been employed by Air Manitoba since 1981, and originally flew the Curtiss-Wright C-46. He started flying the HS 748 when it was first introduced into the company in 1985, the report said. "Since then he had completed 10 checkrides on the HS 748; six of these rides were conducted by the same Transport Canada inspector, and two of these were PPC [pilot proficiency check] rides which he failed," the report said.

Four of these checkrides were passed with the same Transport Canada inspector, but the inspector indicated a "'satisfactory with briefing (SB)' on the Transport Canada flight test checklist for item 4(c)(2), missed-approach power loss," the report said. "One ride with an Air Manitoba company check pilot (CCP) also indicated the same SB for [the same checklist item]."

The captain underwent a pilot proficiency check (PPC)/instrument flight check (IFC) on the HS 748 in November 1992. He successfully completed the check, although the inspector administering the check noted: "SB — missed approach — power loss, requires review of exercise — marginal aircraft handling," the report said. The inspector also noted: "Knowledge of aircraft is good, but the pilot becomes very nervous during rides, which contributes to the above comments," the report said.

The area of the checkride in which the captain experienced difficulty included procedures during an overshoot from an instrument approach or a balked landing. "The inspector recalls that the captain was consistently slow to react and, in some cases, did not know the required emergency procedure," the report said. "The inspector's conclusion was that the captain had not prepared for the rides."

The report said that the captain successfully completed all his checkrides in the C-46, and that any difficulties noted during checkrides were related to handling of the HS 748.

At the time of the accident, the captain was the director of flight operations for Air Manitoba, and was "responsible for the establishment of flight operations policy, regulatory affairs and the overall management of flight operations," the report said. "All of the pilots interviewed felt that the captain could effectively handle an emergency situation. They indicated that during an emergency he would not necessarily take control of the aircraft if the first officer was flying, as he had confidence in first officers' abilities."

The interviewed pilots said that the captain was "an easy person to get along with, and he had the personal and professional respect of his colleagues, and was easy to approach in his capacity as director of flight operations," the report said. "He ran his department with a very direct approach. Pilots who had flown with the captain indicated that, while flying, he was considered to be just another pilot. He was not strongly assertive and was always willing to discuss any decisions that needed to be made regarding the in-flight operation of the aircraft. He always got results."

The first officer, age 34, held a Canadian ATPL. He had 6,500 total flying hours, with 1,100 hours in the HS 748. He had been employed by Air Manitoba since 1989.

In 1981, the first officer obtained a Canadian private pilot license. In 1982, he failed the initial flight test for a commercial pilot license, and passed on his second attempt, the report said. One month later, he failed a multiengine flight test during the ground briefing, and successfully completed the flight test several days later. The first officer failed his initial multiengine instrument checkride one month later, and passed on his second attempt, the report said.

In March 1993, "the first officer failed his annual HS 748 PPC ride, and had his instrument rating canceled by the inspector."

From 1984 to 1985, the first officer flew small single-engine aircraft in a commercial visual flight rules (VFR) operation, the report said. In 1986, he renewed his instrument rating. "His rating lapsed, and in April 1989, he failed an instrument checkride; he successfully passed a re-ride ... ," the report said. The first officer then flew single-engine float planes in a VFR operation for several months.

The first officer was hired by Air Manitoba in June 1989 as a crewman on the C-46, the report said. In 1990, he became a first officer on the C-46, and obtained an ATPL in 1991. He was trained and passed a PPC ride on the HS 748 in 1992. "The TC inspector who conducted the ride indicated on the ride report that the pilot needed work on altitude and airspeed control; he commented negatively on a simulated double-engine failure procedure, and concluded by stating that the next ride was to be done by a DOT [Department of Transport] inspector," the report said.

In March 1993, "the first officer failed his annual HS 748 PPC ride, and had his instrument rating canceled by the inspector," the report said. "The unsatisfactory sequences were a check that was completed too slowly, and an instrument holding pattern established incorrectly." One week later, he successfully completed another checkride in the HS 748. In September 1993, the first officer successfully completed a PPC in the C-46 with a company check pilot, the report said.

The report added: "A review of comments made on [the first officer's] flight test reports and training records showed that most of the difficulties noted were related to handling of the aircraft."

The first officer was described as an average pilot by company captains and training pilots who had flown with him, the report said. "They felt he had been steadily improving on the HS 748 aircraft; however, some of them expressed doubts as to how the first officer would react in an emergency situation," the report said. "Some captains indicated that he lacked assertiveness and might be hesitant to react independently. Two captains stated that the first officer sometimes completed checklists too quickly during normal operations, and, as a result, missed items on the checklist. On more than one occasion, these captains had told the first officer to slow down while doing these checks."

The report added: "Other captains stated that the first officer was assertive and spoke out when necessary, handled actual emergency situations professionally and competently, and properly performed his checklist duties. The first officer had recently applied for the vacant company flight safety officer position. [He] thought highly of the captain, and had flown with him quite often in the recent past."

Investigators reviewed the flight crew's working conditions, and found that the "published schedules showed that the flight times did not exceed the established flight time and duty day limits," the report said. The captain had flown 29.3 hours from Nov. 1 to Nov. 5, never exceeding 6.7 hours per day. "He did not fly again until 10 November, when he flew 2.7 hours prior to the crash," the report said. As director of operations, the captain was required to be in his office during regular work hours when he was not flying.

The first officer's duty schedule was also reviewed. "In the first 10 days of November, the first officer flew seven days, being off duty in the fourth, seventh and eighth," the report said. "He accumulated 39.8 flight hours, never exceeding 6.5 hours per day. He flew 6.0 hours on 10 November prior to the crash. The first officer was apparently happy with the flying schedule in that it was regular, reasonable and allowed for scheduled days off."

Investigators tried to determine which flight crew member was flying the aircraft at the time of the accident, by reviewing the injuries and bone fractures sustained by the crew, as well as the damage patterns on the control columns and rudder pedals of the aircraft. "A review of the radiology reports on the remains of this crew did not reveal any evidence to indicate who was flying the aircraft," the report said. "The right control column wheel was badly damaged compared to the left wheel; however, no determination about who was flying could be made from this information."

A review of the weather at the time of the accident flight indicated that "the Sandy Lake area was under the influence of a weak low or frontal wave, with broken-to-overcast cloud layers 3,000 [feet] to 6,000 feet [915 meters to 1,830 meters] ASL [above sea level], with some embedded convective cloud topped between 7,000 [feet] and 8,000 feet [2,135 meters and 2,440 meters] ASL," the report said. "There was a possibility of moderate to severe icing in the cloud, which could have existed in the vicinity of Sandy Lake at the time of the occurrence. The visibility was generally better than five miles [eight kilometers], but at times as low as one-half mile [0.4 kilometer] in snow."

The pilot of a Piper Navajo, which had departed Runway 29 only minutes before the accident flight, "indicated that the ceiling was about 2,000 [feet] to 2,200 feet [610 to 671 meters] ASL (1,000 [feet] to 1,200 feet [305 meters to 366 meters]) AGL, and the visibility was greater than five miles in very light snow," the report said. "He stated that it was a very dark night and that, when the aircraft broke out of the cloud in the climb around 8,000 feet ASL, there was less than 1/4 inch [0.6 centimeter] of ice on the wings."

The investigation reviewed what the normal procedures should have been for the accident flight. "The normal departure for this flight would have been to climb straight ahead, retract the landing gear when safely airborne, retract the landing lights (perhaps after reaching 400 feet [122 meters]), continue climb to 400 feet and retract the flaps, continue climb to the turn altitude (normally 500 feet [152 meters] AGL or greater), and turn 20 degrees to the right en route to Island Lake," the report said.

Investigators determined that the accident flight "had to have been in a turn to the right within seconds of lift-off, [and] it is evident that the pilots thought the aircraft was climbing straight ahead as per a normal departure, even though the aircraft was turning," the report said. "The inoperative gyro compasses would, if manually set, be indicating runway heading while the aircraft was turning, which would reinforce the pilots' belief that the aircraft was flying straight ahead."

The report added: "For the aircraft to be in a turn to the right immediately after takeoff, either the pilot flying was following an erroneous horizon indicator, or he was flying without adequate reference to the available flight instruments. ... After leaving the runway environment, the outside visual reference available to the crew would have been the lights from the houses along the shore to the right of the runway, which, alone, probably would not have provided adequate altitude reference. The lights of the main community would not have been visible until the aircraft was well into the turn."

The report continued: "If the pilots had seen the lights of the community, they would have appeared high in the windscreen because of the steep bank angle of the aircraft, which would have been confusing or added to an already confusing situation. Given the attitude of the aircraft, the pilots would probably have had insufficient time to recover."

The TSB concluded that the crew probably would not have departed Sandy Lake if they had been aware that the AC system was inoperative. The most likely scenario is that the crew did not become aware of the inoperative system until airborne, the report said. "As they continued ... to perform their normal after-takeoff activities, they may have been distracted from their primary task of ensuring that the aircraft remained in the proper flight attitude," the report said.

The report noted: "If the captain or the first officer became aware of the aircraft attitude once the aircraft was at a steep bank angle in the turn, it would have been very difficult for them to orient themselves to their situation and recover in the altitude remaining. Flight path reconstruction and evidence from eyewitnesses suggest that the flight path was constant and indicate that recovery action was not attempted or attempted too late."

A review of the CVR for the flight from St. Theresa Point to Sandy Lake indicated that the captain was flying, the report said. "If the pilots were to have equal time at the controls, it would have been likely that the first officer was flying the aircraft during the departure from Sandy Lake on the accident flight," the report said. "Although it is considered likely that the first officer was flying, without CVR information from the accident flight or eyewitness information, there is no material evidence to determine which pilot was flying the aircraft when it departed Sandy Lake."

Investigators were able to obtain CVR and FDR data for the earlier segments flown by the accident crew from Winnipeg to Sandy Lake (where a missed approach was flown), from Sandy Lake to St. Theresa Point, then back to Sandy Lake. Particular attention was focused on the approaches flown by the crew into Sandy Lake, the report said.

Investigators determined that, on the flight from Winnipeg to Sandy Lake, the crew made two instrument approaches into Sandy Lake before diverting to St. Theresa Point. During the two approaches, the crew did not fly headings or altitudes corresponding to the published nondirectional beacon (NDB) approach procedure for Runway 29 (the only published instrument approach procedure for the Sandy Lake Airport), the report said.

On the second approach, the aircraft descended to 1,200 feet (366 meters) mean sea level (MSL) before discontinuing the approach and diverting to St. Theresa Point, the report said. The published minimum descent altitude (MDA) on the NDB Runway 29 approach chart is 1,740 feet (530 meters) MSL.

When the crew returned to Sandy Lake, "the aircraft flew straight in to Runway 11, descending en route, and landed off the first approach," the report said. "The CVR tape indicates that the ground was reported to be visible from the cockpit just after a verbal call by a crew member at 450 feet (137 meters)." This approach was apparently flown in instrument meteorological conditions (IMC), but there is no published instrument approach procedure to Runway 11 at Sandy Lake, the report said.

The report concluded: "Based on the tracks and altitudes flown, and on the information from the CVR, it is concluded that the crew were using the GPS [global positioning system] as the primary navigation aid while the aircraft was in [IMC]."

The accident aircraft was equipped with a Garmin 100 GPS receiver that was not integrated into the aircraft's navigation system, the report said. "The Garmin 100 GPS installation did not meet the requirements of the technical standard order (TSO) for IFR GPS receivers (TSO C-129); therefore, the GPS could not be approved for use as the primary IFR flight guidance," the report said.

The report related this finding to one of the authorities' concerns: "The TSB has identified other occurrences in which pilots have misused GPS while conducting IFR flights, or in which pilots on VFR flights have continued flight into adverse weather while using GPS and encountered conditions with which the pilot and/or aircraft could not cope. Evidence suggests that both recreational pilots (seeking an inexpensive navigational system) and commercial, passenger-carrying operators are employing GPS in order to get into airports without approved instrument approaches. It is doubtful that these locally improvised GPS approaches take into account the obstruction-clearance criteria used in the design of approved approaches, including the acquisition of valid local altimeter settings."

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

- "[The accident aircraft] was not maintained in accordance with regulatory requirements intended to ensure the safe operation of an aircraft;
- "The GPS installation in [the accident aircraft] was not approved as a primary navigation aid. Indications are that the flight crew used the GPS as a primary navigational aid during the approaches to Sandy Lake, and at times descended below published minimum altitudes while in [IMC];
- "There was no evidence found of any airframe failure, or flight control or engine malfunction;
- "Power was never supplied to the No. 1 AC bus after the aircraft was shut down in Sandy Lake; the reason for this could not be determined;
- "Physical evidence showed that the FDR, CVR and both gyro compasses were not operating when the aircraft took off from Sandy Lake;
- "Completion of the required predeparture checks should have alerted the crew to some, if not all, of the [failure] indications;
- "The MEL prohibits dispatch of an aircraft, at night and in the weather conditions that existed at Sandy Lake at the time of the occurrence, with only one serviceable inverter, or only one horizon indicator, or only one directional gyro compass;
- "The MEL prohibits dispatch of an aircraft with both flight recorders inoperative;
- "Witness marks found at the aileron/wing hinge points suggest that the ailerons, at impact, were positioned to induce a left roll;
- "To crash in the attitude and place that it did, the aircraft had to lift off approximately 1,800 feet [549 meters] from the threshold of the runway, and begin a right turn within a few seconds after lift-off;
- "The crew likely lost situational awareness after takeoff in a gradually steepening spiral turn downwards with a high rate of increase in airspeed;
- "Prevailing company attitudes supported deviating from safe operating practices to achieve overall commercial objectives;
- "Transport Canada inspectors' audit and surveillance of Air Manitoba, prior to the accident, did not uncover serious maintenance discrepancies that were present;
- "There are no procedures in place that require pilot flight-test results to be monitored, by TC or companies, to identify pilots who experience repeated difficulty during flight tests;
- "[The accident aircraft] was not equipped with a standby attitude indicator, nor is there a regulatory requirement that large turboprop aircraft [must] be so equipped; [and,]

- The TSB recommended that the Canadian Department of Transport:

- "Immediately verify through field audit that all existing FDR and CVR installations meet current regulatory requirements, and make public its findings;

- "Revise its approval and monitoring process to ensure that all future FDR and CVR installations continue to meet regulatory requirements;

- "Streamline its processes to facilitate the timely Canadian implementation of updated flight recorder requirements;

- "Amend the *Manual of Regulatory Audits* (MRA) to provide for more in-depth audits of those air carriers demonstrating an adverse trend in its risk management indicators;

- "Ensure that its inspectors involved in the audit process are able to apply risk management methods in identifying carriers warranting increased audit attention;

- "Develop, as a priority, a system to track audit follow-up actions;

- "Implement both short- and long-term actions to place greater emphasis on verification of required audit follow-up action and on enforcement action in cases of noncompliance;

- "Expedite the implementation of approved GPS standards and procedures for use in Canadian airspace;

- "Initiate a national safety awareness program addressing the operating limitations and safe use of GPS in remote operations;

- "Require the installation of an independently powered standby attitude indicator on all turbine-powered, IFR-approved commuter and airline aircraft capable of carrying 10 or more passengers; and,

- "Require the installation of GPWS on all turbine-powered IFR-approved commuter and airline aircraft capable of carrying 10 or more passengers."♦

Editorial note: This article was adapted from *Controlled Flight into Terrain, Air Manitoba Limited, Hawker Siddeley, HS 748 Series 2A, C-GQTH, Sandy Lake, Ontario, 1 nm NW, 10 November 1993*. Report No. A93H0023, prepared by the Transportation Safety Board (TSB) of Canada. The 58-page report includes charts.

ACCIDENT PREVENTION

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