Transportation Safety Board of Canada

Bureau de la sécurité des transports du Canada

AVIATION INVESTIGATION REPORT
A08W0244

CONTROLLED FLIGHT INTO TERRAIN
SUMMIT AIR CHARTERS LIMITED
DORNIER 228-202 C-FYEV
CAMBRIDGE BAY, NUNAVUT
13 DECEMBER 2008

Canada

The Transportation Safety Board of Canada (TSB) investigated this occurrence for the purpose of advancing transportation safety. It is not the function of the Board to assign fault or determine civil or criminal liability.

Aviation Investigation Report

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Report Number A08W0244

Summary

The Summit Air Charters Ltd. Dornier 228-202 (registration C-FYEV, serial number 8133) was on a charter flight from Resolute Bay to Cambridge Bay, Nunavut, under instrument flight rules. While on final approach to Runway 31 True, the aircraft collided with the ground approximately 1.5 nautical miles from the threshold at 0143 mountain standard time. Of the 2 pilots and 12 passengers on board, 2 persons received serious injuries. The aircraft was substantially damaged. The emergency locator transmitter activated, and the crew notified the Cambridge Bay Airport radio operator of the accident via the aircraft radio. Local ground search efforts found the aircraft within 30 minutes, and all occupants were removed from the site within two hours.

Other Factual Information

History of the Flight

Summit Air Charters Ltd. had accepted a charter to transport workers from Resolute Bay, Nunavut, to Yellowknife, Northwest Territories. The crew of two departed Yellowknife at 0640 [1] on 12 December 2008 to position the aircraft. The crew conducted a fuel stop at Cambridge Bay, Nunavut and arrived at Resolute Bay at 1226. The aircraft departed Resolute Bay with 12 passengers on December 12 at 2345. A flight itinerary had been filed with the NAV CANADA North Bay Flight Information Centre. The captain was the pilot flying during the leg to Cambridge Bay, with the first officer as the non-flying pilot.

The aircraft cruised en route to Cambridge Bay at flight level 100, [2] with the crew using a global positioning system (GPS) as the primary navigation aid. Thirteen minutes before the occurrence, during the descent into Cambridge Bay, both GPS displays became unusable for two to three minutes due to signal degradation.

At 0117, when the aircraft was approximately 75 nautical miles (nm) from the airport, the captain briefed the first officer that they would proceed direct to the LEXUP waypoint [3] and conduct a straight-in visual approach to Runway 31 True (see Appendix A—RNAV (GNSS) [4] Runway 31 True). With cold temperature corrections, the minimum sector altitude was briefed for 2200 feet above sea level (asl) and LEXUP crossing at 1200 feet asl. The minimum sector altitude was later adjusted by the captain to 2100 feet asl. The captain's altimeter was set to 30.06 inches of mercury (in Hg). The radar altimeter alert was set at 500 feet agl, and a flaps zero setting was planned. Vref [5] for the planned configuration was established at 105 knots.

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1 All times are mountain standard time (Coordinated Universal Time minus seven hours).

2 10 000 feet above sea level (asl)

3 Final approach fix for the approach to Runway 31 True

4 RNAV indicates the procedure is based on Area Navigation. The equipment required to fly the procedure is indicated in brackets. Example: RNAV (GNSS) indicates a RNAV procedure requiring GNSS (Global Navigation Satellite System), Canada Air Pilot Instrument Approach Procedures – General Pages

5 Vref is defined as the approach speed in the selected landing configuration, *Dornier 228 Pilot's Operating Handbook*, Section 1

At 0134, 16 nm from Cambridge Bay, the crew contacted Cambridge Bay Airport Radio with a position report and estimated time of arrival of five minutes. Airport Radio advised that there was no reported traffic, the wind was at 300° True (T) at 15 knots gusting to 20, and altimeter setting was 30.03 in Hg. A runway surface condition report from an observation at 1548 on December 12 was included; however, the current visibility was not included in this advisory. The radio operator requested a pilot report on conditions after landing. Due to a discrepancy between the two barometric altimeters, which the crew had detected on the previous flight, the captain's instrument was set to the correct altimeter setting, and the altitude reading on the first officer's altimeter was matched with that on the captain's altimeter.

At 0138, five nm north of LEXUP, the aircraft descended out of cloud to 2100 feet asl. Ground features of dark rocks against white snow were intermittently visible to the crew. A descent was then begun to 1200 feet asl. At one nm from LEXUP, the landing gear was selected down, and pre-landing checks were commenced by the first officer. Except for other tasks directed by the captain, the first officer continued these checks until the aircraft contacted the ground.

Data from the Department of National Defence long range radar (LRR) and short range radar (SRR) based at Cambridge Bay provided position and altitude information to aid in the investigation. Track and groundspeed were derived from this data. The last reliable radar returns at 0142:35 showed the aircraft near the extended runway centreline, about 1.9 nm from the threshold of Runway 31 True, and 0.4 nm from the crash site.

Shortly after crossing LEXUP, the captain noticed that the GPS equipment had not automatically sequenced to the missed approach waypoint at the threshold of Runway 31 True. While the first officer reprogrammed the GPS for a direct course to the threshold, the aircraft proceeded southbound on a track approximately 90° to the inbound course to the runway. The GPS indicated the direct course to the runway threshold of 319°T, or 11° greater than the published approach final approach course (308°T). At about 1.3 nm south of the extended runway centre-line, a right turn was commenced, and the aircraft was directed toward the diffused lights from the settlement of Cambridge Bay on a track varying between about 332°T and 020°T. A descent of 400 to 500 feet per minute was initiated at this time. The last available radar altitude data at 0140:53 indicated 810 feet asl when the aircraft was 5.8 nm from the threshold. At 0141:30, the radar altitude 500-foot alert activated, and the first officer brought this to the attention of the captain. There was no further reference made by either crew member in regard to actual or published approach altitudes, and neither pilot monitored the aircraft's altimeters during the remainder of the approach.

The aircraft crossed the extended runway centreline for the second time, 2.8 nm from the runway threshold; at 2.1 nm, a left turn was made toward the runway centreline (see Appendix B - Radar Plot of C-FYEV). When the runway lead-in strobe lights became dimly visible, the captain turned toward the runway. The precision approach path indicator system (PAPI), positioned on the left side of the runway, 1000 feet from the threshold, was not visible to the crew. Due to reflected glare from falling and blowing snow, the captain requested that the aircraft's landing lights be turned off, and confirmed with Cambridge Bay Airport Radio that the runway lights were at maximum illumination level. A maximum of two runway lights were visible to the captain. Fifteen seconds before ground impact, the propellers were set to

SPEEDS HIGH and flaps were set to FLAPS 1. The aircraft contacted the ground in a shallow descent with wings level, on a track of 310°T. It came to rest on flat, snow-covered terrain near the extended runway centreline, 542 feet from the initial point of contact at 70 feet asl.

The occupants evacuated the aircraft immediately through the main cabin door and the emergency window exits. After an evaluation of the state of the aircraft, the crew and passengers re-entered the cabin to reduce exposure to the elements. The crew notified Cambridge Bay Airport Radio of the occurrence and ground rescue personnel found the site within 30 minutes utilizing snow machines. The pilots illuminated the aircraft's landing lights occasionally to help the rescue team find the aircraft.

Weather

Before departing Resolute Bay, the flight crew obtained the 2200 weather for Cambridge Bay which was as follows: wind 250°T at 13 knots, gusting to 19 knots, visibility 8 statute miles (sm) in light snow and drifting snow, broken cloud at 7000 feet above ground level (agl), temperature -25°C, dewpoint -28°C, altimeter setting 30.44 in Hg.

While en route, the crew received an update on the Cambridge Bay weather based on the 2300 observation which was as follows: wind 310ºT at 18 knots, visibility 2 ¼ sm in blowing snow, broken cloud at 2500 agl, overcast cloud at 9000 feet agl, temperature -26ºC, dew point 33ºC, altimeter setting 30.06 in Hg, remarks - visibility variable 1½ to 3 sm.

At the time of the accident a special observation issued at 0137 was in effect. This report indicated the Cambridge Bay weather was as follows: wind 300°T at 14 knots, visibility 1 sm in light snow and drifting snow, overcast clouds at 2000 feet agl, remarks visibility variable ¾ to 1¼ sm. The crew of C-FYEV did not receive this observation.

Flight Crew

Both pilots were qualified to conduct the flight in accordance with existing regulations. The captain had 13 400 hours total time with 802 hours on type. The first officer had 850 hours total time with 470 hours on type. They both had several days off-duty prior to the positioning flight to Resolute Bay on 12 December.

Prior to flying to Resolute Bay, the crew went to bed two hours earlier than usual and woke about four hours earlier than usual. After arriving at Resolute Bay, the crew checked into a hotel and rested for the required period in order to reset their duty day in compliance with flight and duty time standards. During the 10-hour layover, they rested for 8 hours in facilities judged to be conducive to rest and obtained about 5 hours of sleep. They began their next duty day at 2230 when they proceeded to the airport to prepare for the return flight to Yellowknife. At that time, they considered themselves to be well rested; however, crew are often unaware of the extent to which their performance is affected by fatigue. Their previous day's work was accomplished during day hours, and prior to that, their schedule was to work during the day and sleep at night.

The flight from Resolute Bay to Yellowknife was planned to take place during the pilots' normal sleep period. The time of the accident at 0142 approached the time of a normal low in a daytime worker's circadian rhythm when cognitive functions, manual dexterity, reaction time, and reasoning are significantly impaired. [6]

Rest taken during a person's normal waking period is not normally of sufficient quality to be fully restorative. [7] Sleeping in advance of a known requirement to work at night can offset, to some extent but not necessarily all, sleepiness and fatigue. [8] However, even a full eight hours of sleep would not be sufficient to re-set the crew's circadian rhythm for a flight planned late at night. [9] Research has shown that circadian adjustment to a reversed sleep – wake schedule takes at least two days in a tightly controlled laboratory environment, and can require as many as 14 days in a non-controlled environment. During the adjustment period, performance decrements may be evident. [10]

The company did not routinely require its crews to change shifts on short notice. Its fatigue management program followed regulatory requirements which did not include compensation for shift changes.

Aircraft

Records indicated that the aircraft was certified, equipped, and maintained in accordance with existing regulations and approved procedures. C-FYEV was recently acquired by Summit Air Charters Ltd. and this was its first revenue trip. It was equipped with dual Garmin 430W GPS while the rest of the company fleet was equipped with King KLN94 GPS. There was no flight director or autopilot. This was the first time this flight crew had flown C-FYEV. The aircraft was equipped with a cockpit voice recorder. A flight data recorder was not installed and was not required by regulation.

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6 T.H. Monk (1988), Shiftwork: Determinants of coping ability and areas of application, in *Advance in the Biosciences*, page 73, pages 195-207

7 E.D. Weitzman and D.F. Kripke, "Experimental 12-hour Shift of the Sleep-Wake Cycle in Man: Effects on Sleep and Physiological Rhythms," in L.C. Johnson, D.I. Tepas, W.P. Colquhoun and M.J. Colligan (eds.), *Biological Rhythms, Sleep and Shift Work (*New York: Spectrum Publishing, 1981), pages 93–110

8 M.R. Rosekind, P.H. Gander, and D.F. Dinges (1991), Alertness management in flight operations: strategic napping, SAE Technical Paper Series n° 912138

9 K.E Klein and H.M. Wegmann, Significance of Circadian Rhythms in Aerospace Operations (Neuilly sur Seine, France: NATO AGARD, NATO AGARDograph no. 247, 1981)

10 R.C. Graeber (1989), Jet Lag and Sleep Disruption, in M. H. Kryger, T. Roth, and W. C. Dement (Eds.), *Principles and Practice of Sleep Medicine* (pages 324-331). Philadelphia: W. B. Saunders Company

GPS Operations

The company Air Operating Certificate (AOC) included Operations Specification (OPSPEC) 100, which approved instrument flight rules (IFR) en route and approach operations using KLN94 GPS equipment. Conduct of stand-alone GPS operations under IFR were contingent upon pilot training and demonstrated proficiency in its usage, approval of standard operating procedures, and issuance of an operations specification which identified the type of GPS avionics. [11] There were no company records of Transport Canada approval for the Garmin 430W GPS, or of a pilot training and check program for this equipment. Both pilots were trained and flight qualified on the King KLN94 GPS, but had no previous experience or training on the Garmin 430W.

Altimeters

C-FYEV was equipped with two Intercontinental Dynamics Corporation pneumatic encoding barometric altimeters, part number 570-24929-402. One was installed on the left side of the instrument panel in front of the captain (No. 1 altimeter), and one on the right side in front of the first officer (No. 2 altimeter). During their systems checks prior to departure from Yellowknife, the pilots observed a difference in the altitude reading between the two altimeters when set to the same barometric setting. The No. 1 altimeter read about 130 feet higher than the No. 2 altimeter when set to identical barometric settings. Because mode C altitude encoding was installed on the No. 1 altimeter, it was decided to set that instrument to the published altimeter setting, and set the No. 2 instrument to match the resulting altitude reading.

The pilots did not compare altitude readings on the two altimeters with published aerodrome elevations prior to departures. An entry in the aircraft After Start Checklist called for ALTIMETERS - SET RIGHT/LEFT. There were no additional standard operating procedures for detecting altimeter deviations.

After the occurrence, it was noted that the No. 1 altimeter had been set to the correct Cambridge Bay barometric setting of 30.03 in Hg, giving a reading of 175 feet asl. The No. 2 altimeter was set to 30.17 in Hg, and read 200 feet asl.

Both altimeters were examined at the TSB Laboratory where it was determined that the No. 2 altimeter (serial number 2478) was calibrated within the manufacturer’s specifications. It had been tested and re-certified in accordance with *Canadian Aviation Regulation* (CAR) 571, Appendix B, on 22 April 2008 and installed in C-FYEV on 25 April 2008.

TSB testing determined that the No. 1 altimeter (serial number 1386) read 130 feet high. It was noted that the barometric pressure pointer setting mechanism of this altimeter was difficult to turn and felt rough during rotation. When the case was removed, the drive gear (part number 24319) was found to be damaged.

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11 Commercial and Business Aviation Advisory Circular (CBAAC) No. 0123R

The barometric scale and the pointers on the face of the altimeter are set by the movement of separate internal gear trains that are driven and synchronized by a common drive gear (part number 24319) mounted on a knob shaft. The knob shaft is driven by manually rotating the setting knob on the front of the altimeter case.

When the barometric pressure/pointer setting mechanism was disassembled, the dowel pin (part number 25096) fit loosely in the knob shaft bore and drive gear (part number 24319). Because the dowel pin retains the gear on the knob shaft, the difference in the bore/dowel pin measurements allowed end play of approximately 0.006 inch. The altimeter *Component Maintenance Instruction Manual* required that, during inspection, the end play of all rotating assemblies should be 0.003 ± 0.001 inch, unless otherwise specified. The knob shaft was bent approximately one degree between the shoulder and the threaded end, and exhibited tool marks in the area of the shoulder. It could not be determined from records when this damage occurred.

Misalignment of the drive gear due to the bent knob shaft, combined with radial and axial play, resulted in improper meshing of the drive gear and the pointer drive train gear, part number 24593. This resulted in abnormal wear and damage to gear part number 24319, which showed advanced wear rub marks and separation of five tooth tips (see Appendix C - Altimeter Number 1 Gear Damage).

Because the aft end of the drive gear drives only the pointer setting gear train, the failure of the teeth did not affect the setting of the barometric pressure scale. However, when the setting knob was rotated, the failed teeth on the drive gear would slip on the driven gear and the pointers would not move synchronously with the barometric pressure setting gear train. This lack of synchronous movement resulted in the loss of the altimeter calibration. The loss of five teeth on this gear created an offset of 139 feet, consistent with the observed error of 130 feet. [12] Similar damage, although not as extensive, was observed in the No. 2 altimeter and did not result in loss of calibration.

The No. 1 altimeter had been removed from another aircraft in April 2008 due to loss of calibration. It was re-calibrated and re-certified on 10 June 2008, and was installed in C-FYEV on 15 October 2008. There was no record of disassembly and inspection on this instrument.

The *Component Maintenance Instruction Manual* does not specify a life between overhauls, and disassembly is based on condition. A trouble-shooting section indicated that an erratic barometric setting knob could be caused by burred gear teeth. Instructions called for inspection of the gear train and checking for a bent knob shaft. This manual was normally used only by instrument repair facilities and was not available to operator’s maintenance organizations.

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12 The formula for deriving the resultant offset in feet is the number of teeth lost, divided by the number of teeth in the gear, times 1000 feet.

Cambridge Bay Airport

The Cambridge Bay Airport is under the management of the Kitikmeot Region, Government of Nunavut, and is situated in non-radar, uncontrolled airspace. In addition to the RNAV (GNSS) approach, Runway 31 True was served by two other instrument approach procedures using conventional ground-based navigation aids, which C-FYEV was equipped to carry out. Although these approaches were serviceable, the crew did not use their guidance systems for the approach.

- VOR/DME [13] RWY 31 True (GNSS): The minimum descent altitude (MDA) of 400 feet asl and advisory visibility [14] of 1 sm was identical to that of the approach chosen by the crew.
- NDB [15] RWY 31 True: MDA 600 feet asl (517 feet agl), 1 ½ sm advisory visibility.

A PAPI [16] system was installed on the left side of Runway 31 True, 1000 feet from the threshold, and was calibrated to indicate an approach slope of three degrees.

In 2007, the Manager of Transportation Programs, Government of Nunavut, issued Safety Directive # 6 to all airport staff as part of the Airport Safety Program Manual, requiring a weekly inspection of PAPI installations to confirm proper alignment. The responsible contractor at Cambridge Bay was unable to complete this task, and written records were not available from 18 November to 16 December 2008 to verify the calibration of the PAPI. Airport lighting inspections conducted on December 10 and December 14 did not reveal any lighting problems at Cambridge Bay. A notation in the inspection record for December 14 indicated that some blowing snow had accumulated in the PAPI, and it was removed by the airfield maintainer during the routine inspections.

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13 VOR = Very high frequency omnidirectional range; DME = Distance measuring equipment

14 Subject to the approach ban, published landing visibilities associated with instrument approach procedures are advisory. They are not limiting, and are intended to be used by pilots to judge the probability of a successful landing when compared against available visibility reports at the aerodrome to which an instrument approach is being carried out (*NAV CANADA Canada Air Pilot*).

15 NDB = Non-directional beacon

16 Precision approach path indicator (PAPI), which consists of four light units on the left side of a runway, visible for at least four nm, and designed to provide visual indications of the desired approach slope to a runway (Transport Canada *Aeronautical Information Manual*)

The published minimum crossing altitude at LEXUP is 800 feet asl. The MDA at the threshold waypoint is 400 feet asl. Using a constant rate descent to cover the 5 nm between these two waypoints would require less than a one degree angle of descent. At 3.7 nm from the threshold, the point where C-FYEV descended through 500 feet agl, the normal height above ground would be 620 feet agl. From a point 16 nm to the north of Cambridge Bay, the time to conduct the full instrument approach via SEDIX [17] at a ground speed of 120 knots would have been about four minutes longer than the time to proceed direct to LEXUP and then to the threshold of Runway 31 True.

Visual Approaches

The CARs require flight crews to conduct a published instrument procedure in uncontrolled airspace under IFR in instrument meteorological conditions (IMC). Upon arrival at Cambridge Bay, the aircraft was operating in IMC conditions.

Provision is made in the NAV CANADA *Manual of Operations – ATC* (MANOPS) for an aircraft on an IFR flight plan, operating in visual meteorological conditions (VMC) under air traffic control (ATC) control, and having ATC authorization, to deviate from an instrument approach procedure and conduct a visual approach. During the flight from Resolute Bay and during the approach at Cambridge Bay, C-FYEV was operating in uncontrolled airspace and was not under ATC clearance.

Similarly not applicable would be a contact approach. This is defined as an approach wherein an aircraft on an IFR flight plan or flight itinerary having an ATC clearance operating clear of clouds with at least one nautical mile of flight visibility and a reasonable expectation of continuing to the destination airport in those conditions may deviate from the instrument approach procedure and proceed to the destination airport by visual reference to the surface of the earth.

Controlled flight into terrain (CFIT)

Controlled flight into terrain (CFIT) is defined as occurring when an airworthy aircraft under the control of the flight crew is flown unintentionally into terrain, obstacles, or water, usually with no prior awareness by the crew. This type of accident can occur during most phases of flight, but CFIT is more common during the approach-and-landing phase. The risks of CFIT increase under the following conditions: [18]

- visual night operations in IMC;
- uncontrolled airspace, especially uncontrolled aerodromes;
- limited approach lighting; and
- no ATC service.

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[17] SEDIX is a fly-by waypoint associated with the RNAV (GNSS) Runway 31 True approach

[18] Flight Safety Foundation CFIT Checklist

Pilot training programs and standard operating procedures are designed to minimize the risks of CFIT associated with these factors. The company provided CFIT avoidance training biennially (every two years) and company training records indicated that the captain and first officer had received this training within the preceding 12 months.

The Summit Air Charters *Company Operations Manual* (COM) set the minimum visibility for night visual flight rules (VFR) operations at three sm.

The COM required standard calls by the non-flying pilot and acknowledgement by the pilot flying for 100 feet above specified altitudes, including the minimum descent altitude on an instrument approach. There was no such requirement on a visual approach.

Analysis

Visual Approach

From the time the flight left Resolute Bay until the occurrence, the visibility at Cambridge Bay deteriorated from 8 sm to as low as ¾ sm. The last observed visibility provided to the crew was variable from 1½ sm to 3 sm in snow and blowing snow and, as such, the weather was fluctuating below VFR limits. The crew would have been required to conduct an approach in accordance with instrument flight rules (IFR). By abandoning the full instrument approach and conducting an abbreviated visual approach, the flight reverted to visual flight rules in reported weather conditions below VFR minimums. This reduced the protections against controlled flight into terrain afforded by adherence to published instrument procedures and associated company standard operating procedures (SOP).

Monitoring of Altitude

The crew members' duties were not defined in their briefing for the approach. Except for minimum sector and LEXUP crossing altitudes, no other minimum descent altitudes, including the final approach descent profile or missed approach procedures, were discussed. Therefore, when the aircraft prematurely descended below the minimum altitude for the instrument approach, there was no trigger for the crew to terminate the approach. In low visibility at night over unlit terrain, it would have been difficult to visually judge height above the ground.

During the approach, the first officer's attention was focused on re-programming the GPS and actioning the pre-landing checklist. The captain's attention was directed outside the aircraft while flying with visual reference to the obscured lights of the town and the airport. Except for calling the 500-foot radar altimeter alert, there was no other monitoring or cross-checking of altitudes on the approach by either pilot. When the aircraft was at 500 feet agl, it was about 120 feet lower than would have been required for a constant descent profile for the instrument approach.

GPS Training

Although the pilots of C-FYEV had been trained to use the KLN94 GPS, they were not trained in the use of the installed Garmin 430W GPS equipment. Therefore, during the accident flight, they were qualified to conduct IFR operations using only ground-based navigation aids as their primary source of navigation information. Their unfamiliarity with the GPS equipment and their difficulty in properly setting it up likely provided a distraction to the task of monitoring the proper lateral and vertical approach profiles. The full VOR/DME approach to Runway 31 True would have allowed the crew to make the approach using familiar equipment. This approach has the same minimum descent altitude and advisory visibility limits as the approach they were using.

Altimeters

During the flights from Yellowknife, Cambridge Bay, and Resolute Bay, there was a difference in readings between the two altimeters installed in the aircraft. The pilots recognized this discrepancy and compensated by setting the first officer's instrument to match the altitude reading on the captain's altimeter. The crew did not determine that the captain's altimeter was in error, although it would have been possible to determine which instrument was faulty by comparing altitude readings on the ground at known altitudes. Because altitude was not monitored in relation to aircraft position in the late stages of the approach at Cambridge Bay, it is unlikely that this error played a significant part in the occurrence. There was no company SOP to detect altimeter errors.

An erratic altimeter barometric setting knob could be a symptom of internal gearing deterioration, which can result in loss of calibration. Because the only reference to this problem is found in the altimeter *Component Maintenance Instruction Manual,* which is not normally accessible to operator maintenance organizations, it is possible that an aircraft would be allowed to operate with a defective instrument with potential for calibration errors. Slippage of damaged gears could result in inaccurate readings.

Fatigue

The crew went to sleep early the night before the flight to Resolute Bay, but woke earlier than normal, likely reducing their sleep quality. Although the quality of the sleep obtained during the following day was likely less-than-optimal because it was obtained in the afternoon, it probably offset the effects of early rising and, to some extent, prepared the crew for the flight back to Yellowknife later that night. However, even a full eight hours of rest would have been insufficient to shift the crew's circadian rhythm and fully offset the performance decrements due to flying late at night when their bodies would have been approaching a circadian low. The perception that an eight-hour rest resets the flight/duty clock is consistent with the current regulations; however, when pilots attempt to fly later on the same day at a period of circadian low, there are likely to be performance decrements because the body's internal clock cannot readily be reset. It is possible that fatigue could have reduced the crew's level of cognitive and decision-making performance during the flight.

PAPI System

The PAPI systems at Cambridge Bay had not been inspected in accordance with the *Airport Safety Program Manual*. Although calibration of the equipment did not have a bearing on this occurrence, there was an increased risk of aircraft misalignment from the proper glide path, especially during night and reduced visibility conditions.

The following TSB Laboratory reports were completed:

LP 006/2009 - Encoding Altimeter Testing

LP 028/2009 – Radar Data Analysis

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

Findings as to Causes and Contributing Factors

1. An abbreviated visual approach was conducted at night in instrument meteorological conditions, which resulted in the flight crew's inability to obtain sufficient visual reference to judge their height above the ground.

2. The flight crew did not monitor pressure altimeter readings or reference the minimum altitude requirements in relation to aircraft position on the approach, resulting in controlled flight into terrain.

3. The pilots had not received training and performance checks for the installed global positioning system (GPS) equipment, and were not fully competent in its use. The attempts at adjusting the settings likely distracted the pilots from maintaining the required track and ground clearance during the final approach.

Findings as to Risk

1. The precision approach path indicator systems (PAPI) at Cambridge Bay had not been inspected in accordance with the *Airport Safety Program Manual.* Although calibration of the equipment did not have a bearing on this occurrence, there was an increased risk of aircraft misalignment from the proper glide path, especially during night and reduced visibility conditions.

2. The flight crew's cross-check of barometric altimeter performance was not sufficient to detect which instrument was inaccurate. As a result, reference was made to a defective altimeter, which increased the risk of controlled flight into terrain.

3. Operators' maintenance organizations normally do not have access to the troubleshooting information contained in Component Maintenance Instruction Manuals for the Intercontinental Dynamics Corporation altimeters. Therefore, aircraft could be dispatched with damaged instruments with the potential for developing a loss of calibration during flight.

4. The flight was conducted during a period in which the crew's circadian rhythm cycle could result in cognitive and physical performance degradation unless recognized and managed.

Safety Action

Summit Air Charters

The company amended company policy and standard operating procedures as follows:

- Approach briefings will be conducted before initiating descent and will cover the critical aspects of the approach.

- In night conditions, a visual (VFR) briefing is acceptable only if the ceiling is above the applicable sector altitude and visibility greater than 5 statute miles (sm). If a night visual flight rules VFR approach is to be conducted, the aircraft cannot descend below the minimum safe altitude (MSA) until established on the final approach track. The briefing will be backed-up with the appropriate navigation aids.

- In instrument meteorological conditions (IMC), an instrument flight rules (IFR) briefing must be completed.

- If a published IFR approach exists, the IFR altitude and track limitations for that runway must be adhered to. In all cases, once established on final approach, descent from the minimum safe altitude may only be made by:

    1) following the approach path indicator lights (if available);

    2) following a stabilized approach path until touchdown; and

    3) following the IFR approach limitations (if available).

- Controlled flight into terrain (CFIT) and crew resource management (CRM) pilot training was enhanced and the frequency was increased from biennially (every two years) to annually.

Government of Nunavut

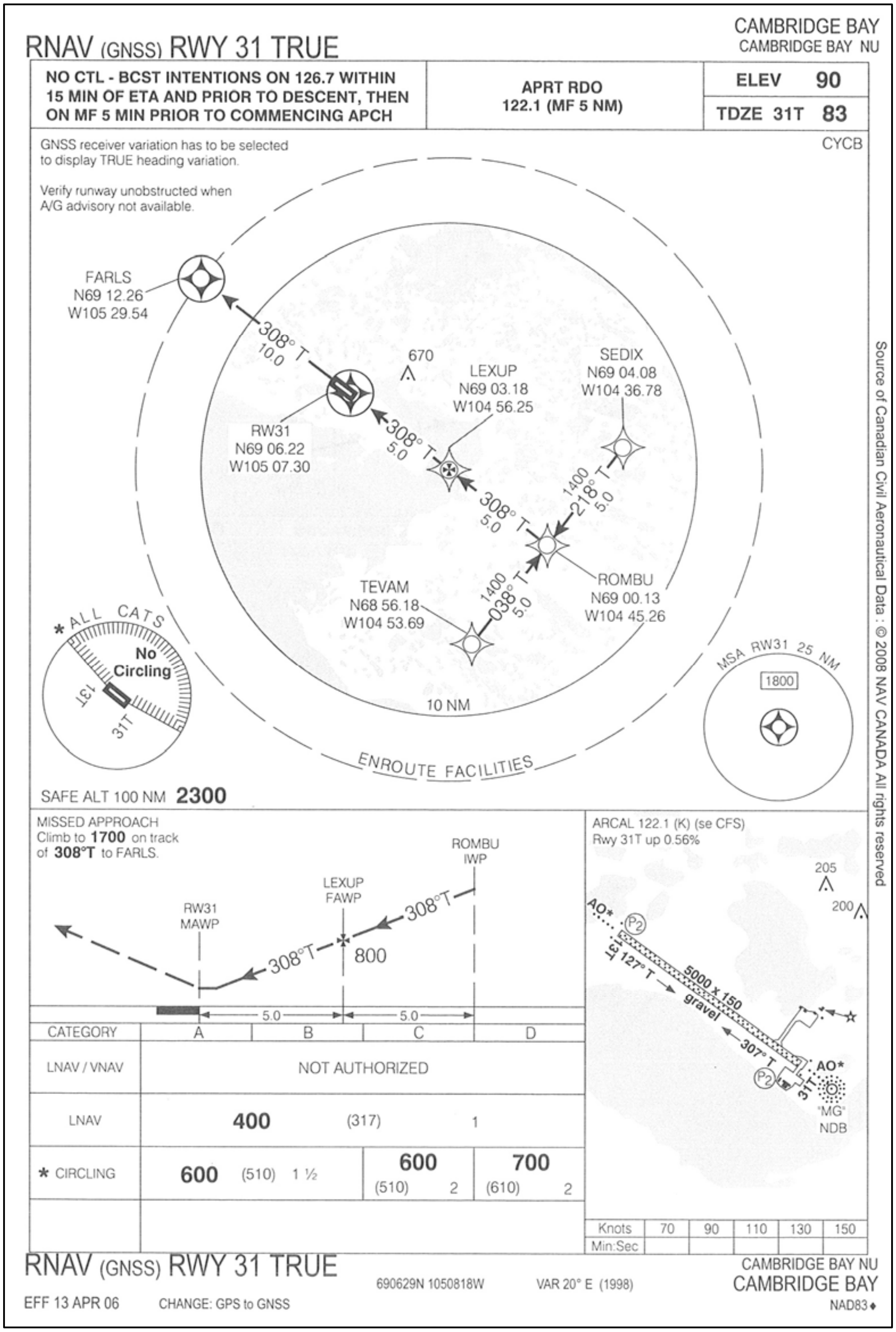
Airport Safety Management Manual

The weekly inspection procedure for precision approach path indicator system (PAPI)/ abbreviated precision approach path indicator system (APAPI) systems at all Government of Nunavut airports has been implemented and emphasized with airport maintenance personnel. The inspections and reports filed with the regional managers are in conformance with Transport Canada publication TP 312, *Aerodromes Standards and Recommended Practices,* and the *Government of Nunavut Airport Safety Program Manual*. Procedures for record retention, including PAPI/APAPI inspections as well as all other required documentation, are being included in the *Airport Safety Management Manual*.

This report concludes the Transportation Safety Board's investigation into this occurrence. Consequently, the Board authorized the release of this report on 23 December 2009.

*Visit the Transportation Safety Board's Web site (**www.bst-tsb.gc.ca**) for information about the Transportation Safety Board and its products and services. There you will also find links to other safety organizations and related sites.*

Appendix A – RNAV (GNSS) Runway 31 True

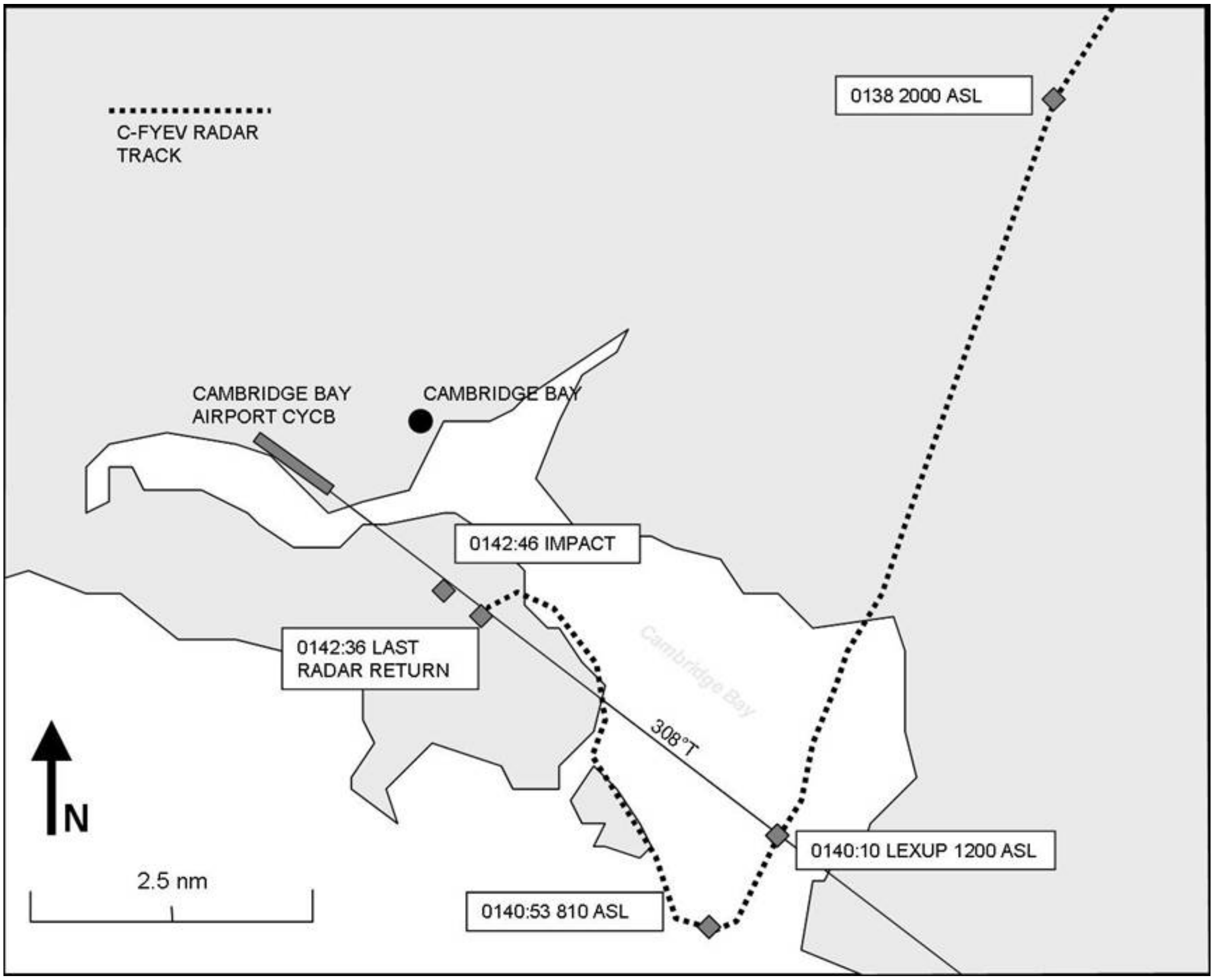


CATEGORY	A	B	C	D
LNAV / VNAV	NOT AUTHORIZED			
LNAV	400 (317) 1			
* CIRCLING	600 (510) 1 ½		600 (510) 2	700 (610) 2

Knots	70	90	110	130	150
Min:Sec					

Not to be used for navigational purposes.

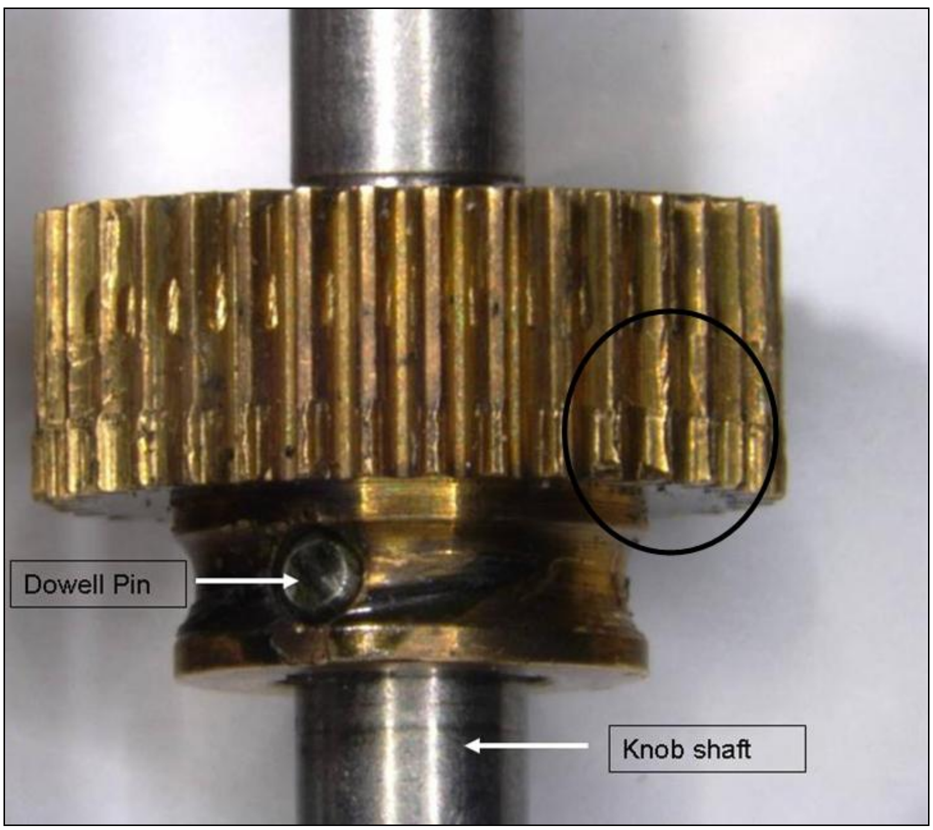
Appendix B – Radar Plot of C-FYEV



Note: The grey area represents land and the white area represents water.

Appendix C – Altimeter Number 1 Gear Damage

Barometric pressure/pointer setting gears



Gear part number 24319 showing representative damaged teeth (circle)