Transportation Safety Board of Canada

Bureau de la sécurité des transports du Canada

TRANSPORTATION SAFETY

REFLEXIONS

Issue 28 – March 2005

AIR

Deceptive Terrain

FADEC Certification Issues

Fuel Leak Followed Maintenance

Canada

Contents

2
Deceptive Terrain

5
The External Load Question

10
FADEC Certification Issues

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Reflexions is a safety digest providing feedback to the transportation community on safety lessons learned, based on the circumstances of occurrences and the results of TSB investigations.

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Cover photograph: Brendan Vanderwerf

Également disponible en français

ISSN 1449-2442

Reduce Risk – Put Safety First

Canada enjoys an enviable record for air safety. Statistics show that accidents and fatalities have been on a downward trend since the late 1990s. Equally impressive, this positive change has coincided with an overall increase in flying activity in the cost-conscious and competitive air transportation industry.

To sustain this trend we will continue to require full knowledge of the factors that contribute to accidents, including the interplay of human and technical factors, policies and procedures, and environmental and safety culture factors.

This is the primary role of the Transportation Safety Board of Canada. Our objective is to learn from past and present events to provide a safer future for the travelling public. As the saying goes, "The supreme purpose of history is a better world." [1]

To ensure a safer future, we must answer three questions during any given investigation: What happened? Why did it happen? And how can we ensure a similar accident won't happen again? Finding out what happened is often the easiest part of an investigation. Determining why it happened – which underlying factors contributed to these acts and conditions, and how the associated risks can be reduced – is much more difficult.

By finding the answers to these three questions, each investigation highlighted in this issue of *Reflexions* will help ensure that industry stakeholders have the insight and information to advance aviation safety.

Canadians will increasingly rely on our air transportation system over the coming years. This presents the industry with new opportunities and new challenges. Can we maintain, and even improve, our enviable safety record in the face of growing demand? The answer will lie in how well the air transportation sector can find ways to reduce its exposure to risk.

Minimizing future risk means learning from the past. We encourage you to consider this issue of *Reflexions* as an important history lesson.

Charles H. Simpson
Acting Chairperson

1. Herbert Hoover, U.S. President, 1929-1933

Tanker 86 delivers retardant to target fire at 1220 mountain standard time.

Deceptive Terrain

Low-level, fire-management flight operations continually challenge the situational awareness of pilots. They require effective crew resource management, and assiduous attention to the terrain and to aircraft performance. A pilot's opportunities to detect obstacles in the flight path can be further reduced by vision limitations resulting from cockpit design and layout characteristics. — Report No. A03P0194

It can be said with some degree of certainty that the pilots of a Lockheed L-188 Electra were unaware that they were on a collision course with the terrain until the very last seconds. The impact that destroyed the aircraft and fatally injured the two pilots occurred 2.5 nautical miles (nm) south of Cranbrook, British Columbia, on 16 July 2003.

The Electra and a Turbo Commander "bird dog" were conducting a fire-management mission on a small ground fire 2 nm southwest of Cranbrook.

On board the Turbo Commander were its pilot and two air attack officers (AAOs) from the British Columbia Forest Service (BCFS). Part of the AAO function is to assess ground fire characteristics and devise the most effective and safe flight paths, retardant dispersal patterns, and delivery profiles. As an integral partner in this process, the bird dog pilot provides operational flight performance input to help the AAO plan and coordinate the attack on the fire. The bird dog pilot helps plan and check the aircraft routes over the drop zones, and leads the tankers into their retardant drop flight paths. Once the planned flight route is decided, the bird dog pilot flies the aircraft on that profile, demonstrating the run for the tanker pilots. During the demonstration flight, the AAO provides a real-time commentary to the tanker pilots, identifying the routes in and out, landmarks, salient points, and hazards along the flight path.

Once the planned flight route is decided, the bird dog pilot flies the aircraft on that profile, demonstrating the run for the tanker pilots.

In the minutes leading up to the accident, the bird dog aircraft flew the approximate route while the AAOs determined that two separate retardant drops, forming a "V," would be required, and that the altitude over the drop zone would be 3700 feet above sea level (asl). A straight-out exit from the first run over the drop zone (heading of about 155° Magnetic) would take the Electra into rising terrain. Therefore, the AAOs decided that the safest exit route was a 35-degree right turn toward Moyie Lake into a wide valley, which was substantially flatter. High-tension power lines crossed beneath the exit route, and although the lines were lower than the proposed flight path, the AAOs included them in their summary as a caution.

Considering the surrounding terrain and the next task, the most practical and reasonable flight path for the Electra after completing the exit from the first drop would have been a climbing left turn to 4500 feet.

After orbiting overhead and observing the bird dog aircraft make its demonstration flights, the Electra pilots confirmed that, after the retardant drop, they would turn right and exit down the valley. They then left their orbit and proceeded on their first run over the fire.

Speeds and Flap Settings

In part, Air Spray's standard operating procedures (SOPs) for the Electra when dropping fire retardant require a 135-knot airspeed with flaps extended to 100 per cent, which equates to a 40° wing flap angle. The SOPs require that, after the load has been released, the pilot apply *maximum continuous* engine power, retract the flaps to 78 per cent (an 18° wing flap angle), and accelerate to 150 knots. At the same time, the pilot manoeuvres the aircraft to fly the planned exit route.

Although not arranged in similar detail as the first retardant drop, it was understood by the AAOs and pilots that, after the first drop, the Electra would climb back to 4500 feet to await the demonstration run for the second drop, that is, the other half of the "V." Considering the surrounding terrain and the next task, the most practical and reasonable flight path for the Electra after completing the exit from the first drop would have been a climbing left turn to 4500 feet.

The bird dog joined the Electra and followed on the left, rear quarter over the drop site. After the Electra released the specified retardant load, the bird dog entered a right-hand turn to circle the fire zone so the AAOs on the right side of the aircraft could assess the drop. At the same time, and as the Electra passed over the power lines, its flying pilot transmitted that they were in the right turn. The Electra was seen to turn right initially, then turn left. About 50 seconds later, the Electra was seen in an extreme left bank angle immediately before it struck the ridge at about 3900 feet asl and exploded. Tree damage and ground impact scars show that the Electra was in a left angle of bank of about 70° and nose-low when it struck the trees.

Performance Calculations

Calculations showed that, immediately after the drop, the Electra could have climbed straight out at approximately 1500 feet per minute (fpm) at 150 knots with *maximum continuous* power and 78 per cent flap, and at about 1000 fpm with a 45° angle of bank.

Further calculations were made to examine the effect on climb performance as a result of dropping all or part of the retardant load. It was determined that jettisoning two 1/6 loads of retardant (9000 pounds) would have improved the rate of climb by about 270 fpm and the stall speed margins by about five knots. Had the pilots used the emergency dump, thereby jettisoning the remaining retardant (22 500 pounds), the rate of climb increase would have been approximately 800 fpm, and the stall speed margin would have improved by 13 knots.

At 78 per cent flap and *maximum continuous* power, the rate of climb is positive for

Once the Electra rolled past a 60º angle of bank with the flaps extended to 78 per cent, the aircraft in all likelihood would have stalled.

any airspeed and bank angle combination between the stall speed and the flap limit speed of 190 knots. However, in level flight with bank angles greater than 60 degrees, the stall speed rapidly exceeds 140 knots. Furthermore, the resulting load factor for such bank angles would make it difficult for the flying pilot to hold the aircraft in a level turn for any length of time. An angle of bank of 70°, for example, produces a load factor of 2.9 g. Once the Electra rolled past a 60° angle of bank with the flaps extended to 78 per cent, the aircraft in all likelihood would have stalled.

Without the likelihood of either aircraft mechanical defect or flight performance inadequacy, the explanation as to why the aircraft did not climb to avoid the terrain becomes one of human performance. With an aircraft capable of controlled, climbing flight, it would be reasonable to conclude that the pilots flew the vertical profile after the drop on the target fire and gently climbed from 3700 feet to at least 3900 feet. It could not be determined if the aircraft climbed more than the observed 200 feet difference, only to lose altitude. It is also possible that, after initiating a satisfactory rate of climb for the seemingly benign task of climbing to 4500 feet, the pilots became distracted and allowed the climb to deteriorate. With no direct knowledge of the cockpit circumstances, the reason why the pilots did not climb their aircraft cannot be identified with any certainty. Nonetheless, several factors exist that collectively lead to a possible explanation.

Visual Deficiencies

Documented research shows that mountainous terrain in daylight, especially at midday with little shadow outline, lacks effective visual definition. It is particularly difficult for pilots to assess slope, proximity, and rate of closure. In such conditions, visual illusion and depth misperception are quite likely.

In this accident, the terrain characteristics were singularly difficult to assess. It is most likely that the Electra pilots were deceived by the apparently gentle sloping nature of the surrounding terrain and did not detect the ridge line that crossed their path. They would have found the ridge line and the protruding land mass difficult to discern clearly until the aircraft was so close that timely and effective evasive action was impossible. Compounding their difficulty in detecting the obstacles ahead were the limitations to unimpeded vision resulting from the left bank in the turn toward the rising terrain, which reduced their perspective and field of vision, and the physical dimensions of the cockpit windshields. It is most likely that the pilots were unaware that they were on a collision course with the terrain until the very last seconds before impact, otherwise they would have altered course and flown the simple, low-level emergency route down the valley toward Moyie Lake.

Action Taken

In the spring of 2004, BCFS Aviation Management Division air attack training sessions reinforced the firebombing procedures, as well as the priorities of runs and exits, specifically in situations where tanker pilots choose to take a different exit or line. They must advise the bird dog crew to allow them the option of rechecking the proposed route for hazards.

The pre-season training and operational practices conducted by contract pilots include the practical use of the aircraft emergency dump systems.

The BCFS Air Tanker Program and the air tanker operators are actively monitoring the delivery of initial and refresher pilot/crew decision making and crew resource management training to all pilots and air staff in the British Columbia program.

Air Spray has placed additional emphasis on human factors and on emergency manoeuvring in mountainous areas. Particular attention has been given to the deceptive nature of mountainous terrain at high sun angles. In its training programs, it continues to stress the deceptive, illusionary nature of mountain flying.

REFLEXION

Once again, we are reminded that flying in mountainous terrain can create visual illusion and depth misperception.

The wreckage on the shoreline of Linda Lake

The External Load Question

The Piper PA-18-150 was over its maximum allowable weight, it had a combination of propeller and floats that were not provided for in the Supplemental Type Certificate (STC), and it carried an external load not authorized under its original Type Certificate (TC). The Piper stalled and crashed while trying to land at Linda Lake, British Columbia, on 04 October 2003, fatally injuring the pilot.
— Report No. A03W0210

The Scenic Air Services Ltd. Piper had been based at the Kawdy Outfitters base camp at Tootsie Lake, British Columbia, for the summer/fall hunting season. The aircraft was being operated under Canadian Aviation Regulation (CAR) 703, "Air Taxi Operations." The flight to Linda Lake was approximately 15 miles. It was the pilot's third return trip to Linda Lake that day and his fourth trip of the day.

The flight was being conducted under day visual flight rules. The pilot intended to pick up moose meat, antlers, and camp supplies at the outfitter's camp at Linda Lake and return it to Tootsie Lake. The aircraft was not heard from after it departed Tootsie Lake. At 1228 local time, the Search and Rescue Satellite System received an emergency locator transmitter signal. At 1346, the outfitter contacted an air operator in Watson Lake, Yukon, by satellite telephone and reported

Aircraft maintenance personnel familiar with the Piper PA-18 aircraft have reported finding similar errors in Piper PA-18 weight and balance amendments.

the aircraft overdue. A helicopter, chartered out of Watson Lake, conducted a search and found the wreckage at 1602 on the shoreline of Linda Lake.

There were no witnesses and no survivor. The immediate circumstances leading up to the accident are unknown. The reported wind direction, the aircraft heading, the position of the flaps at impact, and the location of the accident site are consistent with the accident having occurred during a landing approach. It is therefore probable that the pilot had completed a take-off from the lake, and that he was attempting to return to the lake when the accident occurred. The aircraft was not equipped with a stall warning system that would have warned the pilot of an impending stall, nor was a stall warning system required by regulation. This deficiency has been identified in the past in numerous accidents involving older light aircraft designs.

Weight and Balance

The original production weight and balance report for the aircraft identified the datum as a point 60 inches forward of the wing leading edge. The current TC Data Sheet for the Piper PA-18-150, Aircraft Specification No. 1A2, Revision 37, identifies the datum as the wing leading edge. Some of the references in the original production weight and balance material use the point 60 inches forward of the wing leading edge as the datum, while other references such as the original equipment list and centre of gravity envelope chart use the wing leading edge as the datum.

The aircraft had been last weighed on 18 March 1974. Between March 1974 and August 2001, the weight and balance report was amended three times. Each of the amended reports used the datum 60 inches forward of the wing leading edge to report the empty weight centre of gravity. However, on two of the three amendments, the moment arms for the items listed were mixed between inches from the wing leading edge and inches aft of the datum, and the empty weight centre of gravity was erroneous. Aircraft maintenance personnel familiar with the Piper PA-18 aircraft have reported finding similar errors in Piper PA-18 weight and balance amendments. There are currently 405 Piper PA-18 aircraft in the Canadian registry, 42 of which are registered for commercial purposes.

While centre of gravity does not appear to be a factor in this accident, having two datums for the weight and balance reference material increases the likelihood that errors will occur during weight and balance amendments. This, in turn, increases the potential for an aircraft to be loaded outside the centre of gravity limits. Improper loading could contribute to loss of control, and serious injury or fatality in other occurrences.

It could not be determined if the pilot was aware of the errors in the amended weight and balance reports. The pilot frequently transported hunters and cargo between the main base camp and outlying camps. Since there was no convenient way to weigh each load before take-off, the weight of the cargo on each flight had to be estimated.

The aircraft was equipped with a McCauley 1A175-GM8241 ("Borer") propeller, in accordance with STC SA279AL. However, the STC did not provide for operation of this propeller in combination with the Canadian Aircraft Products 67-2000 floats that were installed on the aircraft.

The pilot had flown moose antlers externally on this type of aircraft many times.

No flight test data were found that documented Piper PA-18 floatplane performance with externally mounted antlers.

External Load

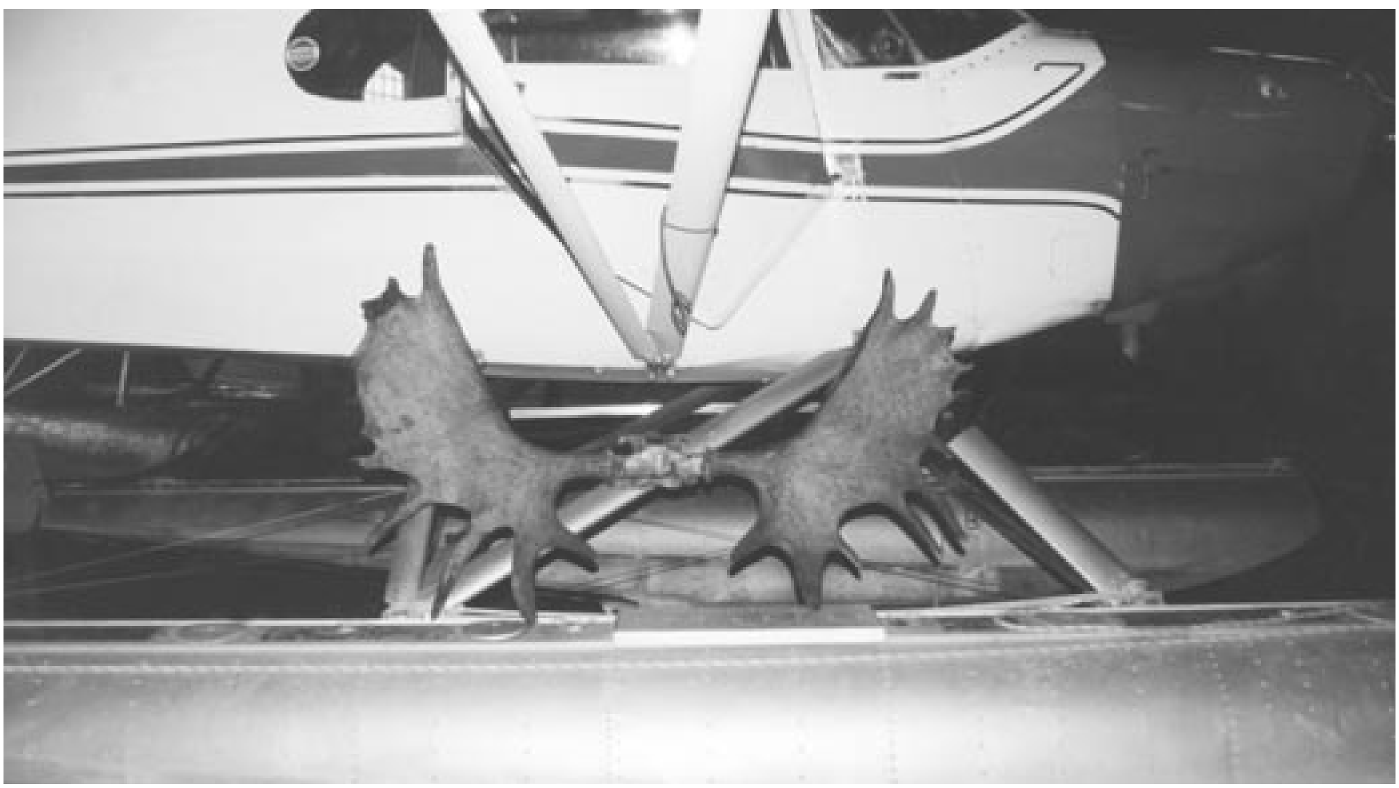
One set of moose antlers was found secured to the right float diagonal strut and entrance step. The antlers spanned 53 inches from tip to tip. They had been tied parallel to the longitudinal axis of the aircraft, above the float deck, with the palms and tips up.

Piper PA-18 aircraft are commonly used by hunting outfitters to transport animal antlers. The cabin space in the Piper PA-18 cannot accommodate large moose and caribou antlers; therefore, the antlers are often carried externally, either on float struts, or on the wing struts of wheel-equipped aircraft. The carriage of external loads is not approved in the Piper PA-18 TC or in any Piper PA-18 STC. The pilot had flown moose antlers externally on this type of aircraft many times.

External loads create parasite drag, which degrades aircraft performance. Animal antlers are not streamlined and may create unusually high drag, considering their size. Several experienced Piper PA-18 pilots were asked about the performance degradation associated with carrying antlers externally. Their comments varied widely, with some pilots reporting little degradation in overall performance and others reporting significant degradation. One highly experienced pilot advised that moose antlers must be secured with the palms down and the tips resting on the float deck, to reduce the airflow disturbance over the tail. No flight test data were found that documented Piper PA-18 floatplane performance with externally mounted antlers.

Canadian Aviation Regulation 703.25 Misinterpreted?

In April 1997, the Canadian Aviation Regulation Advisory Council (CARAC) started to review the carriage of external loads on aircraft. According



Set of moose antlers secured to the right float

There is no specific reference to operations where external loads are carried without passengers on board.

to CAR 703.25, except where carriage of an external load has been authorized in a TC or STC, no operator shall operate an aircraft to carry an external load with passengers on board. The CARAC External Loads Working Group recognized that CAR 703.25, while prohibiting passengers, does not prohibit unauthorized external loads when there are no passengers, and that the regulation could be misinterpreted as allowing external loads without passengers. The working group's final report recommended deleting CAR 703.25 and revising the CARs to accommodate external load operations with and without passengers, private and commercial operations, for aeroplanes and helicopters whose flight authority is not validated by a TC or STC. The CARs have not been revised to accommodate these recommendations.

Transport Canada's Commercial and Business Aviation Advisory Circular No. 0209 informs floatplane operators of an exemption to CAR 703.25. The exemption permits floatplane operators to carry passengers and an external load without authorization in a TC or STC, provided certain conditions are met. The exemption frees the operator from having to comply with the passenger restriction imposed by CAR 703.25. However, there is no specific reference to operations where external loads are carried without passengers on board.

The exemption is subject to several conditions. The *Company Operations Manual* must contain direction to flight crews concerning operations with external loads, and a one-time proving flight is required for each particular type of load. As well, pilots must be briefed and trained in accordance with Section 723.88 of the *Canadian Air Services Standard*. The operating limitations include a requirement to reduce the maximum gross take-off weight of the aircraft by twice the weight of any external load. *Airworthiness Manual Advisory 500/10* provides similar appropriate guidelines for operating aircraft carrying external loads.

Contradictory Information

Scenic Air Services Ltd.'s *Company Operations Manual* contained contradictory information regarding external loads. Section 3.16 of the manual stated that pilots shall not fly company aeroplanes with an external load and passengers on board, unless authorized by a TC or STC. Section 5.11.1 required that pilots be instructed during initial technical ground training about carrying external loads on floats. Section 5.6 stated there would be no carriage of external loads. There was nothing found to indicate that a moose antler, external-load, proving flight had ever been accomplished.

The TSB Aviation Safety Information System database (1976 to 2004) contains records of at least 17 occurrences involving floatplanes carrying external loads. The occurrences involved nine private operators, six commercial operators, and two government operators. A review of the circumstances surrounding 16 of these 17 occurrences indicated that the presence of an external load was a contributing factor, due to the adverse effect of the external load on the aircraft's aerodynamics and performance. Fourteen of the occurrences were accidents due to a loss of control that resulted in a stall or spin. The accidents resulted in 19 fatalities and 6 serious injuries.

The cabin had not been secured for flight, despite the anticipation of turbulent flight conditions.

The empty weight of the aircraft was under-represented in the weight and balance reports, and the aircraft's gross weight was considerably above the allowable take-off weight at the time of the accident. The cabin had not been secured for flight, despite the anticipation of turbulent flight conditions. The right magneto p-lead had been in poor condition for some time, and the discrepancy had not been detected during recent maintenance or operation of the aircraft. The conditions that would most likely have contributed to the loss of control are gusty winds, degraded flight performance due to the aircraft's high gross weight, disruption of airflow because of the external load, and a possible reduction in available engine power due to the faulty magneto p-lead.

The aviation system in Canada relies on built-in checks and balances, such as multiple-person management structures within commercial operations, and regulatory audits to ensure optimal safety. Despite company risk factors that included a recent change of ownership, a history of accidents and incidents, and a management structure that placed all operational and maintenance supervisory responsibilities in the hands of one individual—the pilot involved in this accident—the company had not been audited by Commercial and Business Aviation inspectors since before the original Air Operations Certificate was issued in 1990. It is possible that a Transport Canada audit would have revealed many or all of the unsafe conditions that were identified during this investigation.

Action Taken

On 28 January 2004, the TSB issued an Aviation Safety Information Letter to The New Piper Aircraft, Inc., with a copy to Transport Canada. The letter pointed out the conflict between datum information on the original Piper PA-18 aircraft weight and balance documents and that on the current TC. The information was provided for whatever follow-up action the company deemed appropriate.

On 15 April 2004, the TSB sent an Aviation Safety Advisory to Transport Canada regarding company audits.

REFLEXION

External loads degrade aircraft performance. From 1976 to 2004, the presence of an external load contributed to 16 occurrences, resulting in 19 fatalities and 6 serious injuries.

FADEC Certification Issues

The TSB issued two safety recommendations following its investigation into the in-flight shutdown of an engine on a Cathay Pacific Airways Airbus A340-300 over northern Ontario on 20 October 2002. — Report No. A02P0261

The aircraft, en route from Toronto, Ontario, to Hong Kong, China, with a refueling stop in Anchorage, Alaska, was at flight level 350 when the number 1 engine shut down spontaneously. The pilots, believing the engine had seized, secured the engine and diverted to Vancouver, British Columbia, where the aircraft landed without further incident.

The operation of each of the four CFM56-5C4 engines on the Airbus A340-300 is controlled by the full authority digital engine control (FADEC) system. The FADEC comprises many components, two of which are the electronic control unit (ECU) and the permanent magnet alternator (PMA). The ECU receives electrical power from the aircraft during the engine start sequence. Once the engine has attained sufficient speed, electrical power is provided by the PMA, which is driven by the engine accessory gearbox. Should the PMA fail at any time during engine operation, the ECU, by design, acquires electrical power from another aircraft source. The number 1 engine had accumulated 15 527 hours and

After about 10 minutes, the engine shut itself down.

2622 cycles before the shutdown. The accessory gearbox and the PMA itself had accumulated 15 508 hours and 2619 cycles.

Shutdown not Recorded by the Centralized Fault Display System

Vancouver maintenance personnel printed out a post-flight report from the centralized fault display system (CFDS). The report revealed no indication of the shutdown cause. They then examined the engine by borescope, verifying that the engine had not seized since the engine was rotated during the examination, and checked the accessory gearbox oil filter for contamination. No anomalies were detected. Maintenance personnel performed a non-motoring test to check the engine parameters and the ECU computer system. During this test, the N_2 (rotational speed of the high-pressure compressor in rpm) only reached 14 per cent rpm instead of the expected 28 per cent rpm. According to CFM International (CFM), this lower-than-expected N_2 speed is characteristic of a failure of either the PMA or the ECU. The PMA and the ECU computer were removed. Maintenance personnel noted scoring and burning on the PMA rotor and stator, and assessed excessive play in the drive shaft for the PMA rotor. Post-incident analysis shows that this indicates a potentially damaged drive shaft bearing.

The PMA and the ECU computer were replaced with serviceable units, and another non-motoring test was conducted. In this test, the N_2 reached the required 28 per cent rpm. A full engine test run was carried out but, after about 10 minutes, the engine shut itself down. As with the in-flight scenario, there were no advanced warnings or CFDS record of this shutdown.

Radial and axial movement of the PMA drive shaft alone is not a conclusive indication of bearing condition but, combined with scoring on the PMA rotor, is a reliable indicator of a failed PMA drive shaft bearing. Neither the Airbus A340 maintenance manual nor the fault isolation manual prescribe limits for radial or axial movement of the PMA drive shaft, or contain notations that the scoring of the PMA rotor may indicate a damaged or worn drive shaft bearing. Without such information, maintenance technicians were unaware that the PMA was faulty and dismissed the unusual score marks on the PMA rotor. This additional information would have facilitated more effective troubleshooting and probably precluded the failure of the second PMA during testing, but it is unlikely that it would have prevented the in-flight incident.

When the replacement PMA was removed and inspected, it showed scoring and burning similar to the original PMA. The entire PMA drive shaft assembly—comprising PMA rotor, roller bearing, drive shaft, ball bearing support, and ball bearing—was removed and examined. A visible crack was found in the ball bearing cage that supports the drive shaft where it exits the gearbox. The crack could not be seen with the drive shaft assembly in place in the gearbox. A new drive shaft assembly and a third PMA were then installed, and another engine run was performed, this time without anomaly.

The drive shaft bearing is subject to temperatures as high as 160°C, and it rotates at about 20 000 rpm.

A CFM analysis of the failed ball bearing indicated that there was generalized spalling (that is, small fragments broken from the face or edge of a material) of the balls, wear on the cage pockets (including a fractured pocket), and sectorial spalling on 90% of the inner race. The ball bearing at this location is subject to temperatures as high as 160°C, and it rotates at about 20 000 rpm.

Possible Causes of Bearing Failure

Although the root cause of the spalling could not be determined, it is likely that the initial cause is one of design, of application, or of both. At the time of the incident, the two manufacturers of the bearings were experiencing similar types of failures, although not to the same extent, including an extreme variation in aircraft cycles before failure. Such variation does not lead to reasonable predictability of bearing failure. The bearings were also failing in various aircraft/engine combinations. Likely scenarios that could explain these failures are:

- The bearing may be underdesigned for the application, thereby causing premature failure.
- Oil delivery may be inadequate and oil temperature may be excessive, inducing premature wear, spalling, and fatigue. The origin of the failure on the inner race, 50 to 70 µm in depth, indicates that lubrication is a critical factor within the application.
- Because of the high rpm of the PMA assembly, any instance of incorrect balancing—either initially or after maintenance—may subject the bearing to stresses beyond design tolerances.
- Corrosion of the bearing due to improper storage or maintenance may result in premature failure. However, there was no evidence to suggest that corrosion was a factor in this particular occurrence.

Without electrical power to the ECU, engine conditions were not transmitted to the cockpit instruments or CFDS.

Technical examination revealed that an intermittent short circuit occurred in the PMA when the failure of the ball bearing caused the rotor to contact the stator. The PMA was then unable to generate reliable electrical power for the ECU. The ECU continuously monitors the PMA and, if the PMA no longer generates the required electrical power, the ECU will switch to other aircraft electrical power sources. When it occurs, the switch to other electrical sources is rapid, usually with no significant change in engine performance. In this incident, because of the intermittent nature of the PMA failure, the ECU became stuck in an endless loop of re-acquiring and losing PMA power. With no reliable or consistent source of electrical power, the engine eventually shut itself down. Without electrical power to the ECU, engine conditions were not transmitted to the cockpit instruments or CFDS, thus leading the pilots to believe that the engine had seized.

Subsequently, CFM identified a problem with version C.3.G of the ECU software that prevented the switch-over to other sources of aircraft electrical power. A CFM document, *CFM56-5 Fleet Highlights* (publication 00-01-7263-07), indicates that CFM had been aware of this deficiency since November 1999. Improved ECU software logic for better transfer to aircraft power was developed in early 2000, but was not certified until November 2003. Airbus identified the ECU software revision as a non-critical item. Non-critical ECU software revisions have taken two to three years to implement.

The FADEC system designed for the Airbus A340/CFM56-5C aircraft/engine combination was certified, in part, in accordance with U.S. Federal Aviation Regulation (FAR) 33.28. In general, this rule is intended to minimize the probability that a FADEC system failure will adversely affect an otherwise serviceable engine. Specifically, the intent of FAR 33.28(c) is to ensure that the FADEC provides an engine control system that is considered equivalent in safety and reliability to one based on hydromechanical technology. To accomplish this, the FADEC system must be designed and certified to degrade in a fail-safe manner.

That is, the design and certification process assumes that the FADEC will fail and ensures that the resulting failure condition does not jeopardize continued safe flight and landing. In the case of a loss of PMA electrical power, the FADEC fail-safe design used in the Airbus A340/CFM56-5C aircraft/engine combination relies on ECU software to acquire aircraft electrical power and prevent an unintentional in-flight shutdown (IFSD).

FADEC Deficiency Concerns

Additionally, FAR 33.28(e) requires that all FADEC software be designed and implemented to prevent errors that would result in an unacceptable loss of power or thrust. Assuming that an unintentional IFSD would be categorized as an unacceptable loss of power or thrust, then a validation of ECU software would be required as part of the certification of the FADEC system. However, as this occurrence illustrates, the failure of the ECU to acquire power from the aircraft, due to a known software deficiency, raises concerns about both the continued airworthiness of the FADEC system and the certification process that approved the Airbus A340/CFM56-5C aircraft/engine combination.

Failure of the ECU to acquire other aircraft electrical power during a PMA failure has caused IFSD events in several other recent aircraft incidents and has not been isolated to the Airbus A340 or the CFM56-5C engine.

It is clear that the engine electronic controls should be capable of operation in the event of a total PMA failure; however, with latent deficiencies in the software of CFM56-5C FADEC systems, and potentially with other aircraft/engine combinations, it is likely that an engine will shut down during the loss of electrical power from the PMA.

Software Upgrade

In October 2003, Airbus revised the A340 maintenance manual to include specific checks during the removal of the PMA for evidence of rotor/stator contact and radial play of the PMA drive shaft.

On 13 November 2003, CFM issued a Service Bulletin (SB) that changes the ECU software version from C.3.G to C.3.J and ensures that ECU electrical power successfully reverts to aircraft power in the event of a complete or partial PMA failure.

The actual time frame for accomplishing this SB is at the discretion of the operator.

This SB applies only to the Airbus A340 aircraft and, although CFM recommends implementation within six months, the actual time frame for accomplishing this SB is at the discretion of the operator. Additionally, Airbus advises that it has launched similar initiatives to incorporate software updates on CFM56-5A and -5B engines used on its A319, A320, and A321 aircraft. It is anticipated that compliance for these SBs will likewise be at the discretion of the operator. As of November 2004, approximately 120 aircraft in the Canadian civil aircraft register, most of which are two-engine aircraft, were affected by these SBs.

FADEC system software anomalies may not be confined solely to the Airbus A340/CFM56-5C aircraft/engine combination.

TSB Recommendations

Given the number of aircraft affected, the known problem with PMA bearing failures, the critical function that the ECU software provides in ensuring engine reliability, and the discretionary nature of the proposed software updates, the Board is concerned that, without regulatory intervention, this known unsafe condition will remain in service well beyond the manufacturer's recommended six-month SB implementation time frame. The Board, therefore, recommended that:

> *The Direction Générale de l'Aviation Civile and the Federal Aviation Administration issue airworthiness directives to require the implementation of all CFM56-5 series jet engine service bulletins whose purpose is to incorporate software updates designed to ensure that, in the event of a permanent magnet alternator failure, the electronic control unit will revert to aircraft power.*
>
> ***A04-03***

> *The Department of Transport ensure the continued airworthiness of Canadian-registered aircraft fitted with the CFM56-5 series engine by developing an appropriate safety assurance strategy to make certain that, in the event of a permanent magnet alternator failure, the electronic control unit will revert to aircraft power.*
>
> ***A04-04***

The investigation revealed that FADEC system software anomalies may not be confined solely to the Airbus A340/CFM56-5C aircraft/engine combination. Similar in-service performance anomalies of other Airbus/CFM aircraft/engine combinations have resulted in the initiation of SB action to update the FADEC system software to prevent unintentional IFSDs. Further, the Boeing 777/Rolls Royce Trent 800 aircraft/engine combination has also experienced at least one occurrence in which the ECU did not acquire aircraft power following a PMA failure.

The ECU software, which is intended to prevent an unintentional IFSD, has been deemed non-critical by CFM, thus resulting in a two- to three-year time frame to implement design updates. A two- to three-year time frame to implement an update designed to bring the software into compliance with its basis of certification is incompatible with FAR 33.28.

The TSB believes that recommendations A04-03 and A04-04 will address the safety deficiencies in the existing aircraft fleet, and notes that new engines will incorporate the changes needed to address the specific software problems identified in this investigation. However, the TSB is concerned that the current certification process, specifically as it relates to FAR 33.28(e), may not be sufficiently rigorous to ensure that software deficiencies are identified and corrected before the software is put into general use.

Smoke or vapour coming from the number 2 engine

Fuel Leak Followed Maintenance

On 06 November 2003, shortly after the Calgary, Alberta-bound Air Canada Airbus A330-300 lifted off from Vancouver International Airport, British Columbia, the tower informed the pilots that a substantial amount of smoke or vapour was coming from the number 2 engine. The pilots received no abnormal engine performance indications or warnings from the electronic centralized aircraft monitoring (ECAM) system, but declared an emergency and returned to Vancouver, landing without further incident. — Report No. A03P0332

Maintenance

The previous day, during a routine service check of the Airbus, maintenance personnel found fuel leaking from the drain mast on the number 2 engine, a Rolls-Royce RB211 TRENT 772B-60/16. Further investigation showed that the fuel was leaking from the air/oil heat exchanger, which cools engine oil. The fuel leak exceeded the limits prescribed in the Airbus A330 troubleshooting manual (TSM).

Maintenance entered the defect, including the corrective action required, into the aircraft maintenance logbook and removed the aircraft from service. The aircraft was then towed to an Air Canada hangar to replace the air/oil heat exchanger.

By mistake, a notation was made on the maintenance office duty board indicating that the aircraft required a fuel/oil heat exchanger replacement instead of an air/oil heat exchanger.

Subsequently, a maintenance team of three licenced aircraft technicians was assigned to replace the fuel/oil heat exchanger.

Missing Retainer

The technicians reviewed the air/oil heat exchanger defect in the logbook, noticed the discrepancy with the duty board and decided to check the fuel/oil heat exchanger first. Two of the technicians, one of whom had Air Canada maintenance release authority for the Airbus A330 and the TRENT 700 engine, began troubleshooting the suspected leak. When they disconnected a low-pressure (LP) inlet coupling to the fuel/oil heat exchanger, fuel sprayed from the disconnected line. Confirming that the fuel/oil heat exchanger was not the source of the leak, the technicians prepared to reconnect the LP fuel line and ordered replacement seal rings.

Some time later, the inlet coupling was reattached to the fuel/oil heat exchanger and the three bolts were tightened to the correct torque. However, a retainer, a crucial component to the security of the coupling, was omitted. During the time it took for the replacement seal rings to arrive, the retainer, which cannot be removed from the fuel line, slid down the fuel line, becoming obscured from view.

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The technicians who removed the LP fuel line were unfamiliar with the style of coupling used and did not refer to the Airbus A330 TSM, nor did they refer to all relevant sections and pages of the aircraft maintenance manual (AMM) when removing or reinstalling the LP fuel line. In addition, the removal and reinstallation of the LP fuel line was not recorded on any maintenance documents, contrary to Air Canada's maintenance policy manual and Transport Canada regulations. Once the LP fuel line was reinstalled, the connection was inspected for leaks and security from an elevated platform in the hangar.

The two technicians resumed troubleshooting the fuel leak, this time using the TSM, and determined that the source was the air/oil heat exchanger, as identified in the logbook. It was also noted during this troubleshooting sequence that the LP connection on the fuel/oil heat exchanger was not leaking fuel. They removed and replaced the defective air/oil heat exchanger.

During the required six-minute idle-engine run, the fuel pressure and low fuel-flow rate, combined with minimal engine vibration, were insufficient to simulate in-flight conditions. Therefore, the LP fuel line did not detach from the fuel/oil heat exchanger, despite the missing retainer. After the idle-engine run, the reconnected components were inspected for leaks, but none were found. The fuel/oil heat exchanger was inspected from the ground rather than from an elevated position, as required by the AMM, where a thorough inspection could be completed. Furthermore, a developer, which would have made detecting fuel leaks easier, was not used. However, given that the LP coupling can appear secure without the retainer in place, along with the technicians' unfamiliarity with this particular fitting, it would have been difficult to detect whether the retainer was missing, even from an elevated position. As well, the seal rings on the LP fuel line had been compressed sufficiently to prevent any leaks, rendering the developer, even if it had been used, ineffective in detecting the missing retainer.

After the idle-engine run, the reconnected components were inspected for leaks, but none were found.

Take-off Power Made the Difference

The next day, as the power levers were advanced for take-off, the pressure in the LP fuel line increased from 100 pounds per square inch (psi) to approximately 190 psi at take-off power, while the fuel-flow rate increased from 685 kg per hour to 9000 kg per hour. Data from the flight data recorder indicate that, at take-off power on this flight, the fuel loss was calculated to be approximately 20 000 kg per hour, yet the engine continued to run normally. These increases and, perhaps, engine vibration caused the LP fuel line to detach from the fuel/oil heat exchanger because the retainer was missing, resulting in a large vapour trail.

The crew was alerted to the vapour trail and took appropriate action. Without this alert, it could have taken the pilots some time to detect that the fuel was disappearing, since on-board equiment did not indicate a fuel problem. Air Canada had not implemented Airbus Service Bulletin (SB) A330-28-3080, which alerts pilots to a potential fuel leak once there is a loss of 3500 kg of fuel. Implementing this SB reduces the risk of fuel exhaustion, engine shutdown, and fire. On this flight, a 3500 kg fuel loss occurred in fewer than five minutes following departure.

Follow-up Action

Following the occurrence, Air Canada issued an Airbus A330 Maintenance Alert instructing technicians to consult the appropriate technical publications and follow instructions for maintenance or troubleshooting, and to record all work performed in the appropriate records.

Air Canada also expected to have Airbus SB A330-28-3080 implemented on its A330 fleet by the fall of 2004.

On 03 March 2004, the TSB sent Safety Advisory A030025-1 to Transport Canada, indicating that it may wish to review current aviation maintenance practices and procedures regarding engine run-up procedures. Specifically, the advisory targeted maintenance practices and procedures following maintenance on fuel and oil systems to ensure that potential fuel leaks are detected. In systems where fluid pressures and flow rates change dramatically from idle to take-off power, the application of take-off power may be required to ensure the integrity of the system.

Transport Canada responded that it was of the opinion that the industry-wide impact in imposing a task to run-up engines at full power to detect fuel and oil leaks must be carefully considered, as there are insufficient data to support such a decision. Documented statistics that engine idle-power run-ups do not detect all leaks during leak check tests are required to support a task change substantiation for take-off power run-ups. Given the information provided, it is Transport Canada's recommendation that the procedures as written in the Airbus A330 AMM are sufficient, and when followed, would detect a leak at idle-power run-up. Transport Canada said that it would publish an article in *Aviation Safety Maintainer* on fuel/oil leak engine test runs after maintenance.

Vapour trail behind the aircraft

The aircraft struck the ice-covered surface of Hamilton Inlet, Newfoundland and Labrador.

Little Margin for Error or Mischance

It was the middle of winter, the Cessna 210N aircraft's turn coordinator was unreliable, the heater did not work, and there was no automatic direction finder. Yet, the ferry pilot and daughter departed Narsarsuaq, Greenland, on a flight to Goose Bay, Newfoundland and Labrador, on 14 February 2003.
— Report No. A03A0022

When the aircraft departed Narsarsuaq under instrument flight rules (IFR) on a direct routing over the ocean at 14 000 feet, temperatures at altitude were below -30˚C. To compensate for the lack of heat in the aircraft, both occupants wore multiple layers of clothing under their cold-water survival immersion suits.

In darkness, at 1800 local time, while 23 nautical miles (nm) from the Goose Bay Airport, the aircraft had descended to 2000 feet and was cleared for

At 1808, just inside 6 nm from Goose Bay, the pilot radioed that the attitude indicator had failed.

a straight-in precision approach radar (PAR) to Runway 26. Air traffic control radar data show that the aircraft proceeded inbound at 2000 feet to 2100 feet, with occasional small corrections to maintain the on-course track. At 1808, just inside 6 nm from Goose Bay, the pilot radioed that the attitude indicator had failed. The PAR controller immediately reverted to "No Compass" approach procedures, advising the pilot to disregard the compass.

Shortly after the pilot's transmission, the aircraft veered left, descended rapidly to 1400 feet, then levelled on a northerly heading. The PAR controller then discontinued the approach and attempted to aid the pilot by advising of necessary corrections to the flight path. The aircraft stayed on a northerly heading for approximately 20 seconds, climbing gradually to 1600 feet. It then entered a spiral dive to the left.

The turn coordinator was observed to be unserviceable during the final flights before departure.

The wreckage of the aircraft was found several hours later on ice-covered Hamilton Inlet; both occupants were fatally injured.

Extensive Repairs

Despite an airworthiness certification in December 2002, the aircraft was in generally poor mechanical condition when it was picked up by the operator in January 2003. The aircraft underwent extensive repairs in Exeter, England, and Prestwick, Scotland. Mechanical deficiencies with the aircraft were subsequently resolved to the point that the aircraft was capable of proceeding with the flight.

The local flying club at Prestwick flew two flights with the aircraft on 08 February 2003 and four flights on 09 February. On 11 February, the vacuum filters as well as the engine oil and oil filter were reportedly changed. The flying club then flew two final flights, with the last flight on the evening of 11 February. None of the flying club pilots noted any anomalies with the attitude indicator; however, the turn coordinator was observed to be unserviceable during the final flights before departure. Furthermore, some significant deficiencies, such as an expired emergency locator transmitter (ELT) battery, poor cabin heating, the lack of an automatic direction finding (ADF) receiver, and the unserviceable turn coordinator, were not corrected prior to departure.

The aircraft departed Prestwick for Reykjavik, Iceland, on an IFR flight plan on 12 February 2003. The aircraft was equipped to the point that it could be navigated along an IFR route; however, it was not equipped for IFR flight or for night visual flight rules (VFR) flight.

When the aircraft arrived in Reykjavik, the pilot, who had over 5000 reported flying hours with 110 trans-Atlantic ferry flights, commented that the aircraft's turn coordinator was unserviceable, and the aircraft's heater was not working well. The pilot did not, however, have these items serviced. The flight was delayed a day in Reykjavik due to a winter storm and departed for Narsarsuaq at 0730 Atlantic standard time. On arrival at Narsarsuaq at 1140, the pilot and daughter were chilled from lack of cabin heat and pressurization. They went to a nearby hotel restaurant for lunch.

It is not known why the pilot selected an alternate airport that did not meet forecast alternate weather requirements.

The lack of heat may have had two adverse effects. The three-hour stopover in Narsarsuaq may have been due, in part, to recover from previous cold exposure. The lengthy stopover resulted in an arrival at Goose Bay one hour after sunset. In the frigid en route temperatures, lack of cabin heating may also have caused frosted aircraft windows. Both darkness and frosted windows would have decreased the likelihood of acquiring visual references during the spiral dive; however, it is not known if any of the aircraft's windows were frosted.

Weather Forecasts

The weather forecast that the pilot received at Narsarsuaq indicated VFR conditions for Goose Bay, with a TEMPO (temporary fluctuation) condition of 2000-foot ceilings and visibility of 2 statute miles (sm). These weather conditions were well above the PAR approach limits, and may have prompted the pilot to attempt the flight.

The pilot filed Churchill Falls, Newfoundland and Labrador, as the alternate airport. The weather forecast for the planned time of arrival there was 1/2 sm in light snow and blowing snow, with a vertical visibility of 500 feet. There was also a TEMPO condition, spanning the entire forecast period, which indicated a visibility of 2 sm in light snow and an overcast ceiling of 1000 feet. The actual weather at Churchill Falls was below alternate limits throughout the day. In addition, the aircraft was not equipped with the necessary navigation equipment (ADF) to conduct an IFR approach there. Furthermore, the aircraft did not have sufficient fuel to meet the *Canadian Aviation Regulations* IFR alternate fuel requirements. It is not known why the pilot selected an alternate airport that did not meet forecast alternate weather requirements.

REFLEXION

The general mechanical condition of an aircraft is vital to its safe operation.

Over the Ocean, Lost, and Low on Fuel

The Canadian crew of a Convair 580 were led to safety by a USAF C-141 Starlifter after the crew became lost while en route from Pago Pago, American Samoa, to New Zealand on 18 June 2003.
— Report No. A03F0114

The Kelowna Flightcraft Air Charter Ltd. Convair, C-GKFJ, was being delivered to its new owners in Palmerston North, New Zealand, with stops in Honolulu, Hawaii, and Pago Pago. From Pago Pago, the planned route was to take the flight through waypoints BAVAK, RUGRO, FAROA, AUTEL, IBESO, the GS (Gisborne) VOR (very high frequency omni-directional radio range), the WO NDB (non-directional beacon) and

There would have been significant differences between the GPS magnetic track and distance, and those shown on the flight plan.

the NR VOR, and NZPM (North Palmerston International Airport). For this leg, the aircraft had 18 200 pounds of fuel on board, and the estimated fuel burn was 12 000 pounds for the expected flight time of 6 hours 28 minutes. The flight departed at 2040 Universal Coordinated Time (UTC).

The Convair was equipped with two global positioning system (GPS) units. Standard aviation safety procedures and practices call for flight crew data verification to be entered into long-range navigation systems. Kelowna Flightcraft Air Charter Ltd. has procedures to be followed when conducting operations in oceanic airspace. They mandate that, during the preflight check of the long-range navigation system, the flight crew shall enter and confirm the planned flight route. The company also states that "If not stored as a standard route, waypoints for [an] Operational Flight Plan route must be entered into the GPS. Whether stored or not, both the pilot flying and the pilot not flying will verify the entered route during the preflight checks prior to departure confirming both waypoint designator and LAT/LONG of the waypoint."

No Cross-checks Performed

At no time before any of the three legs of the flight between Canada and New Zealand did the 14 000-hour pilot or 3000-hour co-pilot check and compare the waypoints, bearings, and distances between waypoints, as entered in the GPS, against the computer-generated flight plan. The TSB investigation determined that the last six waypoints of the last leg—IBESO, GS VOR, WO NDB, NR VOR, PN VOR, and NZPM—had been entered with west longitude coordinates instead of the correct east longitude coordinates.

AUTEL is east of the 180° meridian and had been entered correctly with west longitude coordinates. Since IBESO, the next waypoint and west of the 180° meridian, was the first waypoint entered incorrectly into the GPS, with west instead of east longitude coordinates, there would have been significant differences between the GPS magnetic track and distance, and those shown on the flight plan.

The GPS would have shown a track of 174° Magnetic (M) and a distance of 425 nautical miles (nm), instead of the correct track of 186° M and 458 nm shown on the flight plan. Had the crew confirmed the flight plan track and distance to IBESO on passing AUTEL, it would have been apparent that there was a discrepancy between the flight plan and the GPS coordinates.

Since all longitudes from IBESO on were entered as west instead of east, all GPS distances from IBESO on would have been the same as the flight plan distances, but all GPS tracks would have differed significantly as follows:

IBESO to GS VOR—140° M
instead of 185° M

GS VOR to WO NDB—105° M
instead of 207° M

WO NDB to NR VOR—107° M
instead of 207° M

NR VOR to PN VOR—106° M
instead of 205° M

"11 Minutes" Out, but no NAVAIDS

At 0210 UTC, C-GKFJ established very high frequency (VHF) radio communication with Ohakea terminal, reporting that they were estimating Gisbourne in 11 minutes, yet were unable to receive the GS VOR or any other ground navigational aid. The Ohakea controller gave C-GKFJ a transponder code to squawk and asked for their distance to Gisborne, which they reported as 80 nm.

The controller was unable to see or identify the aircraft on radar.

The controller was unable to see or identify the aircraft on radar, and requested that C-GKFJ tune in the low-frequency radio broadcast station 2YA, frequency 567 kHz, and report the bearing. The crew reported that automatic direction finding homing was very poor because of thunderstorm activity, but the most reliable bearing appeared to be astern.

The result was a display of airports and VORs in North America.

The controller then requested that C-GKFJ squawk 7700 and activate the emergency locator transmitter (ELT). The crew immediately tuned the transponder to 7700, but activated the ELT, which was located on the rear cabin bulkhead, later when they had time. They requested and received clearance to descend to flight level (FL) 180 and to proceed directly to the Palmerston North VOR. They lost VHF communications with Ohakea at 0230.

Both of the aircraft's GPSs indicated that the aircraft was approaching Palmerston North, yet the crew members were unable to contact any air traffic control (ATC) facility on either VHF or HF radio. The crew decided to descend and verify their position visually. Although unable to obtain a descent clearance from any ATC facility, they descended from FL 180 to 3000 feet when their GPS indicated that they were about 50 nm from their user-defined Palmerston North waypoint. They broke out over the ocean.

Had they been where the GPS indicated, the descent would have brought them into possible conflict with New Zealand domestic air traffic and into close proximity to terrain, as they would have been in the vicinity of the Ruahine mountain range with elevations reaching 4000 feet to 5900 feet above mean sea level.

Because of their inability to contact any ATC facility, the crew began to doubt the functionality of the GPSs and radios. Since the aircraft had experienced a lightning strike earlier, the crew believed that this might be the cause.

The crew activated the GPS nearest waypoint function. This function displays the ten nearest airports, five nearest VORs, and five nearest waypoints. The result was a display of airports and VORs in North America and five user-defined waypoints, starting with IBESO.

Neither company management nor the crew understood how GPS databases are set up, although it is clearly described in the GPS manual. Had they understood the GPS better and believed that no data card for the route to be flown was available, they probably would not have dispatched the aircraft with the North American data card installed. Installing the North American data card

At this point, fuel remaining was less than 2000 pounds and they declared an emergency.

deactivated the internal airports and VOR databases, which cover every public-use airport and VOR in the world. Had the North American data card been removed before the crew used the nearest waypoint listing, the GPS would have returned a display of airports and VORs in New Zealand instead of North America.

The crew discussed the situation and, in view of the 60-knot westerly wind that they had been experiencing for some time, concluded that they were most likely east of New Zealand. They ignored their GPSs, turned to a heading of 270°M, climbed to 12 000 feet (the best altitude for range), and set the long-range cruise power of 930 horsepower on each engine. At this point, fuel remaining was less than 2000 pounds and they declared an emergency. They made numerous Mayday calls on VHF 121.5 and various high frequencies without a response.

About 300 nm off Course

The captain then pushed the present position function on the primary GPS, obtained a position of 40˚10'00" south, 176˚10'00" west, and plotted on a Jeppesen chart. This plot indicated that the aircraft was approximately 300 nm east-southeast of the closest point in New Zealand, that is

Gisborne. Fuel calculations indicated that there would be very little fuel remaining on arrival at the Gisborne Airport.

At this time, the ground engineer folded up the rubber ferry tank fuel bladders to extract the maximum amount of fuel, and prepared the liferaft for possible deployment. He then joined the pilots in the cockpit to review the ditching drill.

At 0322, the USAF C-141 responded to C-GKFJ's Mayday calls and established communication with them. The C-141 diverted towards C-GKFJ's supposed position and located the aircraft at 0431 using traffic collision avoidance system equipment. The C-141 kept station with the Convair and issued periodic track corrections and distance-to-run to Gisborne until about 48 nm from the Gisborne VOR, then departed for Christchurch, New Zealand.

When C-GKFJ was approximately 69 nm from Gisborne, VHF navigation and communication radios started to operate normally. The aircraft landed safely at Gisborne at 0508 with about 360 pounds of fuel remaining, sufficient for only a few more minutes of flight.

Flight plan track versus actual track flown

Errors More Common Than Thought

On 02 December 2003, the TSB sent an Aviation Safety Advisory to Transport Canada outlining the manner in which the crew entered and used GPS information without confirming the accuracy of the entered waypoint information.

Transport Canada (TC) acknowledged that navigation data entry errors are more common than originally thought. However, TC believes that regulatory standards relating to long-range navigation are adequate, and that safety education and promoting adherence to standard operating procedures will be more effective than regulatory action in reducing the risks associated with navigation data entry. As a safety promotion activity, the Advisory was the subject of an article in *Aviation Safety Letter* 2/2004.

REFLEXION

The GPS is an important tool when operating an aircraft. However, data must be entered correctly for it to be accurate.

Aviation Occurrence Statistics

	2004	2003	2002	1999–2003 Average
Canadian-Registered Aircraft Accidents[1]	**252**	**295**	**274**	**305.0**
Aeroplanes Involved[2]	206	242	210	247.8
Airliners	3	7	6	6.6
Commuters	1	9	6	8.0
Air Taxis	42	35	41	45.6
Aerial Work	8	17	12	16.8
Corporate	4	2	2	3.8
State	2	3	4	2.6
Private/Other[3]	145	169	139	164.4
Helicopters Involved	41	44	56	49.0
Other Aircraft Involved[4]	9	12	10	11.6
Hours Flown (thousands)[5]	**3809**	**3790**	**3713**	**3883.0**
Accident Rate (per 100 000 hours)[6]	**6.6**	**7.8**	**7.4**	**7.9**
Fatal Accidents	**24**	**32**	**30**	**33.4**
Aeroplanes Involved	18	26	22	25.4
Airliners	0	0	0	0.4
Commuters	0	0	0	0.8
Air Taxis	3	5	4	4.4
Aerial Work	0	3	1	1.6
Corporate	0	0	0	0.6
State	0	0	2	0.6
Private/Other	15	18	15	17.0
Helicopters Involved	4	3	6	6.0
Other Aircraft Involved	2	4	3	3.0
Fatalities	**37**	**59**	**50**	**60.0**
Serious Injuries	**26**	**43**	**42**	**43.4**
Canadian-Registered Ultralight Aircraft Accidents	**36**	**46**	**36**	**38.0**
Fatal Accidents	6	7	9	7.8
Fatalities	10	9	12	11.4
Serious Injuries	7	14	4	8.6
Foreign-Registered Aircraft Accidents in Canada	**20**	**30**	**13**	**22.2**
Fatal Accidents	3	6	1	5.4
Fatalities	10	8	2	9.0
Serious Injuries	2	3	0	2.0
All Aircraft: Reportable Incidents	**907**	**834**	**865**	**795.2**
Risk of Collision/Loss of Separation	222	154	193	176.0
Declared Emergency	277	292	280	251.8
Engine Failure	143	132	160	156.6
Smoke/Fire	94	103	101	96.4
Collision	21	16	22	14.4
Other	150	137	109	100.0

1 Ultralight aircraft excluded.
2 As some accidents may involve multiple aircraft, the number of aircraft involved may differ from the total number of accidents.
3 Other: Contains, but is not limited to, organizations that rent aircraft (i.e. flying schools, flying clubs, etc.).
4 Includes gliders, balloons and gyrocopters.
5 Source: Transport Canada (1996 to 2004 hours flown are estimated).
6 Accident rate does not include "Other Aircraft Involved."

Figures are preliminary as of January 11, 2005.

AVIATION Occurrence Summaries

The following summaries highlight pertinent safety information from TSB reports on these investigations.

FOR REASONS UNKNOWN

TSB investigators were unable to determine why a Cessna 208B Caravan departed controlled flight and crashed near Summer Beaver, Ontario, on the night of 11 September 2003. The pilot and the seven passengers were fatally injured. — Report No. A03H0002

The Wasaya Airways Caravan departed Pickle Lake, Ontario, at 2057 local time, and its lights were last seen as it joined the downwind leg of the Summer Beaver airport traffic circuit. It crashed approximately where it would have been turning onto the base leg. Visibility was greater than 10 miles, with moderate turbulence.

Between 01 March 2001 and the date of the accident, nine replacements of the flight command indicator (FCI) were recorded in the aircraft's technical records. The reasons for these replacements varied from the instrument displaying erroneous pitch and bank information while in level flight to the unit not erecting properly or toppling. The FCI was so damaged by the fire that its serviceability could not be determined.

The aircraft was nearly consumed by fire, except for the outer parts of the wings. It did not carry flight recorders. Lack of information about the cause of this accident affects the TSB's ability to identify related safety deficiencies and issue safety communications intended to prevent accidents that could occur under similar circumstances.

Since the occurrence, the operator has provided maintenance personnel with additional training for handling gyro instruments. The company has also increased its flight-following capabilities and, although not required by regulation, the company has adopted a policy of crewing passenger flights with two pilots.

GIVE CARBURETTOR HEAT TIME TO WORK

The pilot properly suspected that carburettor icing was the cause of his engine problem, and selected carburettor heat ON. But he did not give it time to work.
— Report No. A03O0285

The Toronto Airways Limited Cessna 172N, with a pilot and three passengers on board, departed the Toronto/Buttonville Municipal Airport, Ontario, for a sightseeing flight over Toronto at about 1300 local time on 09 October 2003.

Shortly after leveling off at 2000 feet above sea level (1300 to 1400 feet above ground), the Lycoming O-320-H2AD engine began to lose power. The pilot informed the Toronto/City Centre Airport air traffic controller of the power loss and the intention to return to Buttonville.

Trying to regain power, the pilot ensured that full throttle was selected, checked the positions of the primer and magnetos, and switched fuel tanks. When these attempts were unsuccessful, the pilot selected the carburettor heat to the hot position, observed a further decrease in engine power, and reset the carburettor heat to the cold position. The engine was not producing enough power to maintain flight and return to the airport, so the pilot searched for a suitable location for a forced landing. The aircraft was over a densely populated area, and the only suitable clearing was surrounded by trees and nearby buildings. The engine lost power on final approach. The pilot selected the flaps to the full-down position, overflew the clearing, and stalled the aircraft into the trees. The aircraft was substantially damaged, and one passenger received minor injuries.

The aircraft was over a densely populated area, and the only suitable clearing was surrounded by trees and nearby buildings.

When carburettor heat is selected ON, engine power is reduced because of the lower volumetric efficiency of warmer air, which results in a richer mixture. As the ice melts, it is ingested into the engine intake as water, increasing engine roughness and further reducing power. To compensate for the power loss, the throttle must be increased, if possible, and the mixture leaned appropriately. It requires time for the warmer air to eliminate the ice formation and allow the engine to regain power. Further loss of power after carburettor heat application should have been anticipated.

RIGHT SEAT, WRONG SEAT

> *The captain chose to fly the aircraft from the right seat during a night departure when not current to operate the aircraft from the right seat.*
> *— Report No. A03C0029*

Further, the captain did not set the instrument lighting correctly for the night take-off and was unable to use the artificial horizon effectively. This caused loss of situational awareness after take-off and, subsequently, loss of control of the aircraft.

Bearskin Airlines Flight 359, a Beech 99, took off from Runway 27 at Pikangikum, Ontario, on 29 January 2003 on a night visual flight rules flight to Poplar Hill, Ontario. About 400 feet above ground level, the pilot flying (PF) began a climbing right turn en route. The first officer was setting climb power as the PF started the turn. The PF intended to establish the aircraft in a bank angle of 20° to 25°. However, the PF was unable to see the artificial horizon clearly because he had adjusted the instrument lighting on the right side of the cockpit to a lower setting. Although the aircraft was banked to one of the marks on the artificial horizon, the PF was uncertain of the bank angle that was reached. The PF concentrated on the artificial horizon, even leaning forward trying to identify the bank angle displayed. The PF was completing the roll-out of the turn when the first officer told the PF that the aircraft was descending at 2000 feet per minute.

The PF pulled back on the control column. When the first officer saw the frozen surface of the lake approach rapidly (visible because one landing light was still on), the first officer also grasped the control column and pulled back. However, their combined effort did not prevent the aircraft from striking the frozen surface of the lake. The aircraft struck in a wings-level attitude with the landing gear retracted and bounced, finally coming to a stop about 1.5 nautical miles from the departure end of Runway 27. The two pilots and three passengers were not injured.

The Beech 99 after it struck the frozen surface of the lake

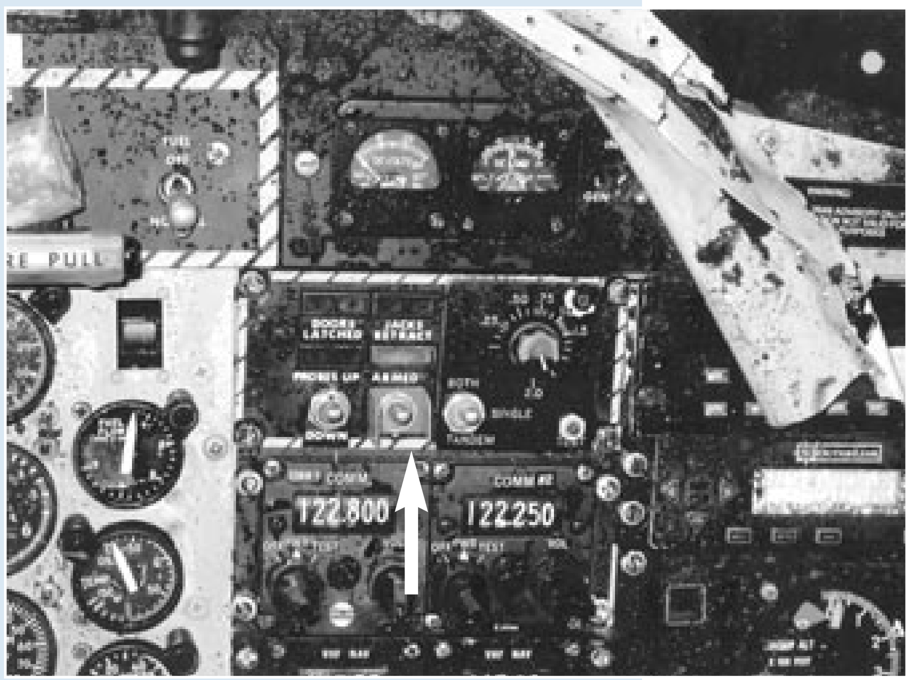
The PF was replacing the flight's original first officer, who was taken ill. For seniority reasons, the flight's original captain became the first officer, and the replacement pilot became captain. The PF had completed currency requirements for the left seat, but not for the right seat and, consequently, was not current to operate the aircraft from the right seat.

After the accident, Transport Canada met with company officials. They agreed to amend standard operating procedures to state that, after take-off, no turns will be performed below 1000 feet above ground level unless air traffic control so instructs. Transport Canada also completed a scheduled routine company conformance audit. The company was addressing issues arising from the audit.

VITAL ACTION CHECKLIST NOT FOLLOWED

The pilot of an Ontario Ministry of Natural Resources (MNR) de Havilland DHC-6-300 amphibious aircraft was scooping water for a firefighting operation. As he approached Lake Wicksteed, Ontario, on 05 June 2003, he performed the inbound checks, lowered the water probes to begin filling the float water tanks, and touched down on the lake. Within a short time, he observed water spraying from the overflow vents located on top of the floats, indicating that the tanks were filled. He pressed a button on the yoke to retract the probes, and the aircraft immediately nosed over into the lake and began to sink.
— Report No. A03O0135

During a scooping operation, the pilot presses the push button probe switch to lower the probes. After touchdown, engine power is increased and yoke back pressure is applied to maintain the planing attitude while the tanks are filling. When the tanks are full, the probe button is pressed a second time and the probes retract. After lift-off, when the aircraft attains a positive rate of climb, the bomb door armed switch on the centre panel is selected ON, and the bomb doors can then be opened by the bomb door push button on the yoke.



System indicating lights and door armed switch (indicated by white arrow) in the ON position

Prior to scooping, the bomb door armed switch on the centre panel must be selected OFF to prevent inadvertently activating the bomb door-open operation if the bomb door push button switch is pressed. The armed switch should be ON only after the scooping operation is complete, and the floats have cleared the water surface. The door armed switch was found ON after the occurrence.

During the approach, the Vital Action Checklist was not completed as per the standard operating procedures, and the bomb door switch was left in the ON position. After completing the scooping operation, the pilot intended to retract the probes by pressing the probe switch, but inadvertently pressed the adjacent bomb door switch. Since this system remained armed from the previous bombing run, the doors extended into the water. The drag from the doors and the water rushing into the floats through the door openings resulted in the aircraft nosing over. The proximity of the probe and bomb door switches, and a missing hinged cover plate on the bomb door switch increased the likelihood of selecting the bomb door switch instead of the probe switch. The cover plate had not been re-installed following maintenance.

The MNR has verified that every Twin Otter in its fleet is equipped with the cover plate over the bomb door push button switch. The MNR will ensure that any future modifications to aircraft will be standardized to decrease the potential for inadvertently operating systems.

Investigations

The following is *preliminary* information on all occurrences under investigation by the TSB that were reported between 01 January 2004 and 31 December 2004. Final determination of events is subject to the TSB's full investigation of these occurrences.

DATE	LOCATION	TYPE OF AIRCRAFT	PHASE OF FLIGHT	EVENT	OCCURRENCE NO.
JANUARY					
13	La Grande, Que., 160 nm SSW	Boeing 777-200 Boeing 767-300	En route En route	Loss of separation	A04Q0003
15	Dryden Regional Airport, Ont.	Fairchild SA227-AC	En route	Loss of directional control – runway excursion	A04C0016
17	Pelee Island, Ont., 0.5 nm W	Cessna 208B	Take-off	Collision with terrain	A04H0001
19	Toronto/Lester B. Pearson Int'l Airport, Ont.	Airbus A321-211	Taxiing	Nosewheel axle failure	A04O0016
26	Toronto/Lester B. Pearson Int'l Airport, Ont.	Boeing 767-233	Take-off	Aircraft pitch-up – stall warning on departure	A04O0020
FEBRUARY					
20	Kumealon Inlet, B.C.	Robinson R22 Mariner	En route	In-flight breakup	A04P0033
25	Edmonton Int'l Airport, Alta.	Boeing 737-210C	Landing	Landing beside the runway	A04W0032
29	Ruskin, B.C.	Lake LA-4-200 Buccaneer	En route	Collision with water	A04P0041
MARCH					
03	Vancouver Int'l Airport, B.C.	Boeing 737-200 Cessna 182D	Taxiing Landing	Risk of collision on the runway	A04P0047
04	Swift Current, Sask., 4 nm SW	Bell 206B	En route	Loss of visual reference – collision with terrain	A04C0051

DATE	LOCATION	TYPE OF AIRCRAFT	PHASE OF FLIGHT	EVENT	OCCURRENCE NO.
08	Saint-Hubert, Que.	Schweizer 269C-1	Standing	Separation of main rotor on run-up	A04Q0026
12	Nanaimo, B.C., 20 nm N	Cessna 185E Cessna 185F	En route Manoeuvring	In-flight collision	A04P0057
20	Ralph, Sask.	Baby Belle	En route	In-flight breakup – collision with terrain	A04C0064
31	Québec/ Jean Lesage Int'l Airport, Que.	de Havilland DHC-8-300	En route	Control difficulty	A04Q0041
APRIL 07	London, Ont.	Cessna 172M Boeing 737-200	En route En route	Air proximity	A04O0092
08	Mount O'Leary, B.C.	Cirrus Design SR20	En route	Loss of control – parachute system descent	A04P0110
19	Chibougamau–Chapais, Que.	Beech A100 Beech B100	Landing Approach	Runway overrun Air proximity	A04Q0049
22	Timmins, Ont.	Raytheon B300	Approach	Aircraft stall during instrument approach	A04O0103
28	Tasu Creek (Queen Charlotte Islands), B.C.	Bell 206L	En route	Power loss – first engine	A04P0142
MAY 05	Vancouver Int'l Airport, B.C.	de Havilland DHC-8-100 de Havilland DHC-2 (Beaver)	Take-off Take-off	Air proximity	A04P0153
08	Thetis Island, B.C.	Cessna 305A	Manoeuvring	Loss of control	A04P0158
15	Tabusintac, N.B., 2 nm E	Eurocopter AS350-B3	Manoeuvring	Main rotor overspeed – difficult to control	A04A0050

DATE	LOCATION	TYPE OF AIRCRAFT	PHASE OF FLIGHT	EVENT	OCCURRENCE NO.
18	Fawcett Lake, Ont.	de Havilland DHC-2 Mk. I	Unknown	Loss of control – collision with terrain	A04C0098
28	Greater Moncton Int'l Airport, N.B.	Boeing 727-225	Landing	Wing scrape during a rejected landing	A04A0057
JUNE					
07	Taltson River, N.W.T.	Cessna A185F	Landing	Upset on water landing	A04W0114
11	Bob Quinn Airstrip, B.C.	McDonnell Douglas 369D	Manoeuvring	Hard landing	A04P0206
13	Québec/ Jean Lesage Int'l Airport, Que.	Airbus A320 Cessna 172S	Take-off Take-off	Risk of collision	A04Q0089
14	Gatineau, Que., 2 nm SE	de Havilland DHC-2 Mk. I	Landing	Collision with water	A04H0002
25	Flourmill Volcano, B.C., 5 nm W	Eurocopter AS350-B2	Standing	Blade strike and rollover	A04P0240
JULY					
14	Ottawa/ Macdonald-Cartier Int'l Airport, Ont.	Embraer EMB-145	Landing	Runway overrun	A04O0188
18	Stanley Airport, N.S.	Schreder HP 18 (amateur-built glider)	Take-off	Aerodynamic stall – loss of control	A04A0079
AUGUST					
05	Québec, Que.	Cessna 208B Beech B300	En route En route	Air proximity	A04Q0124
13	McIvor Lake, B.C.	Robinson R22 Beta	Manoeuvring	Collision with water	A04P0314
19	Saint John, N.B.	Piper PA-31-350	Approach	Collision with terrain – fire	A04A0099

DATE	LOCATION	TYPE OF AIRCRAFT	PHASE OF FLIGHT	EVENT	OCCURRENCE NO.
26	Ashern, Man., 15 nm SW	Piper PA-28-235	En route	Flight into adverse weather – collision with terrain	A04C0162
31	Greater Moncton Int'l Airport, N.B.	Boeing 727-200	Landing	Loss of control – runway excursion	A04A0110
31	Nain, N.L., 45 nm NW	Aerospatiale AS-350D	Approach	Loss of control – collision with terrain	A04A0111
SEPTEMBER 02	Peterborough, Ont.	de Havilland DHC-8-100	En route	Flight control system malfunction	A04O0237
10	Edmonton City Centre Airport, Alta.	Beech C90A	Approach	Missed approach	A04W0200
21	La Ronge, Sask.	Fairchild SA227-AC	Landing	Landing gear collapse – runway excursion	A04C0174
OCTOBER 14	Halifax Int'l Airport, N.S.	Boeing 747-200	Take-off	Collision with terrain	A04H0004
30	Shepherd Bay, Nun.	Bell 212	Take-off	Collision with terrain	A04C0190
DECEMBER 01	Saint-Georges, Que.	Beech B300	Landing	Collision with object	A04Q0188
05	St. John's Int'l Airport, N.L., 10 nm SW	Piper PA-28	Unknown	Collision with terrain	A04A0148
16	Oshawa, Ont.	Shorts SD3-60	Landing	Runway overrun	A04O0336
19	Gaspé, Que.	Piper PA-31-350	Landing	Collision with terrain	A04Q0196
24	Kuujjuaq, Que.	Beech A100	Landing	Runway excursion	A04Q0199
28	Invermere, B.C., 16 nm S	Robinson R44	En route	Collision with terrain	A04P0422

Final Reports

The following investigation reports were released between 01 January 2004 and 31 December 2004.
*See article or summary in this issue.

DATE	LOCATION	TYPE OF AIRCRAFT	REPORT NO.
01-10-08	Mollet Lake, Que.	de Havilland DHC-2 Mk. I	A01Q0166
02-01-20	Patapédia River Valley, N.B.	Piper PA-28-161	A02Q0005
02-02-22	Val-d'Or, Que.	Eurocopter AS 350 BA	A02Q0021
02-05-09	Des Passes Lake, Que.	Cessna 180F	A02Q0054
02-05-13	Toronto/Lester B. Pearson Int'l Airport, Ont.	Boeing 767-300	A02O0123
02-05-18	North Bay Airport, Ont.	Beech A100	A02O0131
02-05-20	Three Valley Gap, B.C.	Bell 206L4	A02P0096
02-06-19	Kamloops, B.C.	McDonnell Douglas 369D	A02P0126
02-07-11	Chitek Lake, Sask.	Bell 205	A02C0161
02-08-07	Smithers, B.C., 10 nm S	Bell 214B-1	A02P0168
02-08-25	Toronto/Lester B. Pearson Int'l Airport, Ont.	Cessna 206 McDonnell Douglas DC-9	A02O0272
02-09-02	Québec/Jean Lesage Int'l Airport, Que.	Mooney M20E	A02Q0119
02-09-07	Orillia, Ont.	Cessna 172P	A02O0287
02-09-10	Gander Int'l Airport, N.L.	McDonnell Douglas DC-8-63F	A02A0107
02-09-11	Halifax Int'l Airport, N.S.	Piper PA-31-350	A02A0108
02-09-11	Pink Mountain, B.C., 20 nm W	Bell 212	A02W0178
02-09-17	London, Ont.	Sikorsky S-76A	A02O0301
02-10-17	Churchill, Man., 290 nm NE	Boeing 777-228	A02C0227
02-10-20	Timmins, Ont., 40 nm W	Airbus A340-300	A02P0261*
02-12-16	Lake Errock, B.C.	Sikorsky S-61N	A02P0320
03-02-02	Halifax Int'l Airport, N.S.	Boeing 737-200	A03A0012
03-02-11	Windsor, Ont.	Airbus A320-212	A03O0034
03-02-14	Goose Bay, N.L., 5 nm E	Cessna 210N	A03A0022*
03-03-05	Gander, N.L.	McDonnell Douglas MD-11 Boeing 757-224	A03H0001
03-03-13	Dauphin, Man., 25 nm SW	Beech C90A	A03C0068
03-03-25	Langley Airport, B.C., 6 nm NE	Piper PA-28-140	A03P0068

DATE	LOCATION	TYPE OF AIRCRAFT	REPORT NO.
03-04-09	Peace River, Alta., 10 nm SE	Robinson R44	A03W0074
03-04-23	Prince Albert, Sask., 6 nm SW	Beech 99A	A03C0094
03-05-22	Lac du Bonnet, Man.	de Havilland DHC-3	A03C0118
03-05-31	Chilliwack Airport, B.C., 7.5 nm E	Cessna 182	A03P0133
03-06-05	Lake Wicksteed, Ont.	de Havilland DHC-6-300	A03O0135*
03-06-06	Ward Creek, B.C.	Bell 206B	A03P0136
03-06-18	Gisborne, New Zealand, 300 nm ESE	Convair 580	A03F0114*
03-06-24	Wasaga Beach, Ont., 5 nm WSW	Mooney M20E	A03O0156
03-06-26	Buchans, N.L., 25 nm SE	Dromader PZL-M-18	A03A0076
03-07-16	Cranbrook, B.C., 2.5 nm S	Lockheed L-188	A03P0194*
03-08-05	Toronto, Ont.	Boeing 767-200 Fokker 100	A03O0213
03-08-10	Princeton, B.C.	Cessna 210A	A03P0239
03-08-11	Port Hardy, B.C., 26 nm W	Boeing 747-400 Boeing 757-200	A03P0244
03-08-23	Vernon, B.C.	Airbus A319-114	A03P0259
03-08-29	Penticton, B.C., 11 nm NE	de Havilland DHC-2 Mk. I	A03P0265
03-09-03	Vancouver Harbour, B.C.	de Havilland DHC-6-100	A03P0268
03-09-23	Calgary, Alta., 49 nm SW	Cessna 414A	A03W0202
03-09-26	Toronto/Lester B. Pearson Int'l Airport, Ont.	Astra SPX	A03O0273
03-09-27	Gaspé, Que.	Piper PA-31-310	A03Q0151
03-10-04	Linda Lake, B.C.	Piper PA-18-150	A03W0210*
03-10-09	Toronto/Buttonville Municipal Airport, Ont., 2 nm SSE	Cessna 172N	A03O0285*
03-11-06	Vancouver Int'l Airport, B.C.	Airbus A330-300	A03P0332*
03-12-16	Jellicoe, Ont.	de Havilland DHC-3	A03O0341
04-02-20	Kumealon Inlet, B.C.	Robinson R22 Mariner	A04P0033
04-03-20	Ralph, Sask.	Baby Belle	A04C0064

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Issue 28 – March 2005

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