AVIATION OCCURRENCE REPORT

IN-FLIGHT FIRE

PERIMETER AVIATION LTD
BEECH AIRCRAFT CORPORATION 95-B55 BARON C-GCIK
THUNDER BAY, ONTARIO 28.5 NM W
22 OCTOBER 1996

REPORT NUMBER A96C0223

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Summary

The Perimeter Aviation Ltd Beech 55 Baron, serial No. TC 1905, departed Atikokan, Ontario, at 0816 central daylight saving time (CDT) for Thunder Bay on a continuation of a single-pilot courier flight that began in Winnipeg, Manitoba, earlier in the day. At 0834, the pilot contacted the Winnipeg Area Control Centre (ACC) Marathon sector controller and advised that he was experiencing an electrical problem with smoke coming into the cockpit. The pilot requested an immediate descent and vectors for an instrument landing system (ILS) approach to runway 07 at the Thunder Bay airport. The aircraft was given a 15-degree turn to the right and was cleared down to 5,000 feet above sea level (asl). Shortly thereafter, radio communication was lost and the aircraft disappeared from radar coverage. Overflying aircraft initiated a communications search, but there was no further radio contact with the aircraft and no emergency locator transmitter (ELT) signal was received. The Department of National Defence Search and Rescue conducted an intensive air and ground search, but the search was hampered by poor ground visibility. The aircraft was located the following day about one mile south of Shebandowan Lake. The pilot did not survive the severe impact.

Ce rapport est également disponible en français.

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[1] All times are CDT (Coordinated Universal Time minus five hours) unless otherwise noted.

Other Factual Information

The aircraft departed Winnipeg with a load of about 550 pounds of bankers' dispatch notes from Winnipeg destined for Fort Frances, Atikokan, and Thunder Bay. The bags were stored in the nose baggage compartment and in the back of the aircraft, behind a cargo net mounted directly behind the pilot's seat. The aircraft left Winnipeg with 700 pounds of fuel, and was not refuelled en route. The aircraft was operating within its design weight and centre of gravity limits.

The pilot's normal practice at the station stops was to shut down the aircraft's right engine to allow the courier driver to approach the aircraft, open the rear baggage door, remove the baggage for that station stop, and load the baggage for the aircraft's destination. At the pilot's first station stop in Fort Frances, the pilot shut down both engines and advised the courier driver that he was having problems with his dash and that his radios were cutting in and out. He stated that there might be a fault with the wiring and that the situation warranted a call to the operator in Winnipeg. The pilot was seen to use the telephone in the airport terminal building for at least five minutes, and then he departed Fort Frances. In subsequent interviews, no company personnel reported receiving a call that morning from the pilot. The company phone lines were reported to be very busy that morning because of general inquiries into flight scheduling due to poor weather, and it is possible that the pilot's call could not get through. A telephone record check disclosed no completed calls made to the operator from the phone the pilot was seen to use.

The station stop at Atikokan was reportedly routine. The courier agent removed baggage from the rear cargo compartment and reported nothing unusual. The pilot obtained an instrument flight rules (IFR) clearance to Thunder Bay through the Thunder Bay flight service station (FSS) remote communications outlet (RCO) at Atikokan. The aircraft departed runway 22 and made a left turnout. Once airborne, the pilot was cleared to 7,000 feet asl by the Winnipeg Centre air traffic controller. The pilot radioed a pilot weather report to the effect that the ceiling at Atikokan was about 10,000 feet asl with good visibility beneath the cloud. The flight continued as scheduled and at 0834:10, the pilot asked for an initial descent clearance for Thunder Bay. Fifteen seconds later, the pilot indicated that he had smoke coming into the cockpit and asked for an immediate descent. The aircraft was cleared to 5,000 feet asl and given vectors to the airport. At 0837:28, the pilot reported that there was a lot of smoke coming in the cockpit and that he was going to have to "do something." The controller cleared the flight to proceed directly to the airport. There was no further response from the pilot.

The distance from Atikokan to Thunder Bay is about 92 nautical miles (nm). The Thunder Bay Radar Modernization Project (RAMP) radar established radar contact with the aircraft as it was climbing through 5,900 feet asl, about 81 nm west of Thunder Bay. The radar received both primary and secondary target information from the aircraft. The aircraft's transponder was providing Mode A (positional) and Mode C (altitude) data, except for the last 30 seconds of the flight, when only Mode A was transmitted. Radar data indicate that, after departing Atikokan, the aircraft climbed to 7,000 feet asl and commenced a descent from that altitude 39.5 nm west of Thunder Bay at 0834:25. Mode C coverage was lost as the aircraft was descending through 3,700 feet asl. The aircraft's average rate of descent from 5,000 feet asl to 3,700 feet asl was 2,900

feet per minute. Radar contact with the aircraft was lost at 0837:51, at a distance of 29.12 nm from Thunder Bay. The wreckage was found 0.7 nm northeast of the aircraft's last radar position.

The Environment Canada weather observation for 0900 CDT at the Thunder Bay airport (elevation 653 feet asl) was as follows: winds calm, visibility 1.5 statute miles in mist, scattered cloud at 400 feet above ground level (agl), broken cloud at 800 feet agl, overcast cloud at 4,400 feet agl, temperature and dewpoint eight degrees Celsius, and altimeter setting 29.88 inches. The remarks associated with the observation noted that the ceiling was composed of 2/8 fog, 4/8 stratus-fractus cloud, and 2/8 stratus-cumulus cloud.

Residents on the ground in the area of the accident reported that, at the time of the accident, the winds were light, the cloud base was at ground level, and visibility was reduced to several hundred feet by fog and mist. The crew of another aircraft flying in the area of the accident at 7,000 feet asl reported that they did not have visual contact with the ground and were between cloud layers with the cloud tops about 10,000 feet asl.

The 28-year-old pilot was hired by the operator in May 1995 and had completed a multi-engine instrument rating. The pilot was then employed as a first officer on the Swearingen SW-3 aircraft type and flew about 1,000 hours on that type. In August of 1996, the pilot underwent flight training on the Beech 95-B55 and passed a pilot proficiency check on that type. The pilot then flew the scheduled courier route to Thunder Bay with that aircraft type in September and October 1996. At the time of the accident, the pilot had accumulated a total of about 1,660 hours of flight time, with about 160 hours on the accident aircraft type. The pilot was described as eager to do his job well and complete the tasks which were assigned to him. However, no information was found to indicate that he was under external pressure to fly an unserviceable aircraft. The operator was reportedly able to arrange alternate means of transportation for the cargo in the event that an aircraft became unserviceable during a courier route.

Part of the pilot's initial flight training on the Beech 95-B55 included training on aircraft emergency procedures. Company personnel indicated that, during this training, they instructed the pilot on the procedures to use in case of electrical smoke or fire. The training outlined the need to isolate the fault and stop any smoke from coming into the cabin, because the smoke could be very incapacitating. The pilots were instructed to shut off all electrical power to isolate the fault, and then attempt to ventilate the cabin. Vacuum-driven flight instruments continue to provide instrument flight reference information. If the smoke subsides, essential systems may then be re-energized, barring any further recurrence of the problem.

The aircraft manufacturer's published procedure for electrical smoke or fire is as follows:

> Action to be taken must consider existing conditions and equipment installed:
>
> 1. Battery and Generator/Alternator Switches - OFF
>
> **Warning - Electrically driven flight instruments will become inoperative.**
>
> 2. Oxygen - AS REQUIRED
> 3. All Electrical Switches - OFF
> 4. Battery and Generator/Alternator Switches - ON

5. Essential Electrical Equipment - ON (isolate defective equipment)
Note Ensure fire is out and will not be aggravated by draft. Turn off CABIN HEAT switch and push in the CABIN AIR control. Open pilot's storm window, if required.

The aircraft was manufactured in 1975 and had been maintained and operated by the company since 1977. The aircraft had accrued approximately 15,112 hours time in service since new. The aircraft last underwent a 50-hour inspection on 09 September 1996 and was due for a 100-hour inspection at 15,120.9 hours. The aircraft was equipped with a vacuum-driven directional gyro and a vacuum-driven artificial horizon, both mounted on the pilot's instrument panel and independent from the aircraft's electrical system. There were no recorded unserviceabilities with these instruments. The aircraft was not equipped with smoke goggles or an oxygen system, nor were these items required by regulation.

The aircraft was equipped with a Halon 1211 fire extinguisher mounted on the floor between the pilot's legs. The fire extinguisher was weighed after the accident and was found to be discharged. The extinguisher was severely damaged, making it impossible to determine whether the extinguisher was discharged by the pilot or as a result of impact damage.

The aircraft struck the ground at an elevation of 1,800 feet asl, and in an estimated 60 degrees nose-down, 90 degrees left-bank attitude on a heading of approximately 050 degrees magnetic. The left wing tip contacted the ground first, leaving an elongated outline of the leading edge of the wing, followed by three craters made by the left engine, nose, and right engine. The aircraft then cartwheeled and broke apart, spreading wreckage over a distance of approximately 620 feet. An initial fire-ball erupted on impact, followed by small, sporadic ground fires which were primarily associated with the remaining fuel in both ruptured wing tanks.

Numerous pieces of the front windscreen were recovered, and the interior surfaces were covered with a thick, black, soot deposit. Soot trails were evident coming from the upper cabin roof-vent and from around the upper cabin door-seal. The cabin door handle was found in the latched position. During the crash, the radios and navigation equipment were torn from the avionics rack and were scattered throughout the wreckage. The radios, which exhibited considerable heat and fire damage, were not located in the areas of the post-impact ground fire. Severe fire damage was noted in the area of the co-pilot's rudder pedals, the co-pilot's side-fuselage foot panel, and the co-pilots instrument panel. A 1/4-inch outside-diameter aluminum fuel line, feeding the right engine fuel-flow gauge and mounted behind the co-pilot's side-fuselage foot panel, was found breached with a large hole in it. The fuel in this line is under pressure during engine operation.

A soot streak was noted flowing out the nose baggage compartment vent, which is located just aft of the nose baggage door on the right side of the aircraft. The vent suffered localized heat damage indicated by burnt paint and metal. The interior of the nose baggage compartment, in the area of the vent, was found to house several relays. Wiring bundles associated with these relays showed signs of severe electrical arcing and fusing. The insulation covering most of the wiring had been burned away. The radio-rack plastic air-cooling line, running from the nose cone area and feeding fresh air to the radios, was found melted and bubbled in the area of the relays. The air-cooling line passes through the forward cabin bulkhead in the area of the co-pilot's rudder pedals.

Following the accident, the aircraft was partially re-constructed and the initial source of heat was determined to have come from the nose baggage compartment in the area of the nose baggage compartment vent. The electrical relays in this area were examined, and no signs of failure were found. The avionics relay, which had been mounted on the aft side of the nose baggage door frame, in line with and just forward of the vent, could not be located. The frame in this area showed signs of heat distress with pieces of the frame broken away. The accident site was revisited, but the relay was not found.

A check with the manufacturer showed that the avionics relay was not a factory installed item. Transport Canada files and the aircraft's technical records (dating back to 1985) were examined, but no documentation or wiring diagram could be found concerning the installation of the avionics relay. Discussions with company maintenance personnel indicate that the relay was most likely installed in the late 1970's or early 1980's. During that period of time, the regulatory guidance for avionic installations came from the *Engineering and Inspection (E&I) Manual* Part 2, Chapter 1, Section 1.9. Installations that were considered major in nature required that documentation concerning the installation be sent to Transport Canada. However, the definition of what constituted a major installation was often open to interpretation, and the installation of the avionics relay may not have been considered a major modification. In any case, the appropriate log-book entries, along with changes to the aircraft's electrical schematic and electrical load analysis sheet, would still have to be made. The only document found to support the installation of the relay was an amendment to the aircraft's electrical load analysis sheet. With the adoption of the *Airworthiness Manual* in 1990 and the new Civil Aviation Regulations (CARS) in 1996, such an installation would clearly be considered a major modification requiring the appropriate documentation.

Technical records indicate that the avionics relay was last replaced on 06 January 1986 at an airframe time of 6,528.7 hours. In February 1993, the aircraft underwent a major avionics and wiring upgrade. New No. 8 bus wires were installed on the battery master and the avionics master relay. On 10 May 1994, the avionics master switch was reported as not being able to shut off the avionics. The problem was traced to a faulty diode on the avionics relay; the diode was replaced. On 07 October 1996, approximately two weeks prior to the accident, the avionics master switch was reported as intermittent and unable to shut off the avionics. The avionics relay was checked with a test bulb to confirm electrical power at the relay terminals. The avionics master switch was cycled several times, and the relay operated normally. The relay terminals were sprayed with a contact cleaner, and the aircraft was returned to service.

The avionics relay manufacturer and part number could not be confirmed through technical records. The operator indicated that the relay's part number was MS24187-D1, manufactured by Cutler-Hammer (Eaton Corporation). The Transport Canada service difficulty report (SDR) data base was checked for reported difficulties with this relay. Four SDR records in varying installations were found. Three SDR records reported the relay as either intermittent or not operating. One SDR record reported white smoke coming from the area of the relay; the relay and a burnt ground wire were replaced. The relay manufacturer was contacted and a search of the manufacturer's data base showed that two relays had been returned to the company in the past year for reasons unknown. The manufacturer indicated that the relay is not field repairable, and that it is

rated for a continuous duty of 50 amperes at 28 VDC for 50,000 electrical cycles. The relay is regarded as an "on condition" maintenance item which does not have to be replaced as long as it is giving satisfactory service.

Analysis

From the wreckage examination and reconstruction, it was determined that the smoke and fire originated in the nose baggage compartment in the area of the nose baggage compartment vent. The progression of the fire damage suggests that a heat source likely ignited a bag of bankers' dispatch notes, causing a localized fire in the nose baggage compartment. The fire quickly melted through the radio-rack plastic air-cooling line and directed hot air and smoke into the cabin. The unlimited source of fresh air from the cooling line likely began a blowtorch effect into the cabin, which breached a fuel line feeding the right engine fuel flow gauge. Given a constant supply of fuel and air, the fire progressed rapidly, causing heavy, black smoke as it burned through the avionics rack and plastic mouldings. This rapid progression of events, from the time of the pilot's first distress call until the time of the crash, took less than four minutes.

The only sources of heat in the area in which the fire originated would have been a short circuit in the aircraft's wiring or a high resistance hot spot, such as a loose terminal on an electrical relay. The relays in this area were examined and there were no apparent signs of failure or loose terminals. The wiring associated with these relays, however, showed signs of severe electrical arcing. The wiring had recently been replaced; therefore, it is unlikely that abraded wiring would have caused an electrical short circuit. It is more probable that the severe arcing was the result of the fire burning off the protective shielding to expose bare wires. The relay in the immediate vicinity of the initiating hot spot was the avionics relay. There had been an intermittent problem with the relay two weeks prior to the accident, which probably reappeared prior to, or at, the station stop in Fort Frances. A loose terminal or a fault within the relay could account for these problems; since the avionics relay could not be located at the crash site, however, its status cannot be confirmed.

Technical records indicate that the relay had been in service for approximately 11 years and 8,555.3 airframe hours prior to the accident. The total electrical cycles on the relay could not be established. A check with the manufacturer and the Transport Canada SDR data base indicates that there were only a few reports of problems associated with this relay. There was one reported case of white smoke coming from the area of the relay; however, the circumstances surrounding that incident could not be confirmed.

When the pilot reported that he had smoke coming into the cockpit, the aircraft was approximately 40 nm from Thunder Bay and between cloud levels at 7,000 feet asl. The aircraft was approximately 18 minutes out of Atikokan and about 16 to 17 minutes out of Thunder Bay, with direct routing. The pilot had just requested clearance to begin his initial descent into Thunder Bay when the problem was reported, and he may have been predisposed to the idea of landing there.

The pilot's initial emergency training on how to respond to electrical smoke or fire reportedly included shutting off all electrical power and isolating the problem. The pilot may have initially assessed the smoke as a recurrence of the intermittent problem he had experienced in Fort Frances, a problem that had evidently

disappeared without warranting shutting down the electrical system. Because of the weather conditions, the pilot knew that he would need the electrically driven navigation and communication equipment to complete the approach into Thunder Bay. As the aircraft descended from 7,000 feet asl, it would have entered the cloud, increasing the pilot's reliance on electrical power for directional guidance. The pilot's radio transmissions and continued secondary radar coverage (transponder operation) indicate that the pilot did not shut off the aircraft's electrical supply to isolate the fault. When the pilot radioed that the smoke was becoming very thick and that he was going to have to do something, the fire was probably out of control. Immediate isolation of the electrical fault likely would have reduced the speed with which the smoke or fire progressed. The aircraft's high rate of descent shortly after the last radio transmission and the aircraft's steep impact angle indicate that the pilot likely became incapacitated because of the smoke and fire.

The following Engineering Branch report was completed:

LP 173/96 - In-flight Fire Investigation.

Findings

1. The aircraft was within its design weight and centre of gravity limits at the time of the occurrence.

2. The pilot was certified and qualified for the flight.

3. Approximately 40 nm west of Thunder Bay, the pilot reported an electrical problem with smoke coming into the cockpit.

4. The pilot reported an intermittent electrical problem at the first station stop in Fort Frances, warranting a telephone call to the operator; however, no record of a completed call was found.

5. The smoke and fire started in the nose baggage compartment in the area of electrical relays and wiring.

6. The avionics relay was mounted in the immediate vicinity of the initiating hot spot; however, the avionics relay could not be located at the crash site.

7. The avionics relay was not a factory-installed item in the aircraft, and proper documentation concerning the installation of the relay could not be found.

8. The pilot was reportedly trained to shut off all electrical power to isolate the fault when confronted with electrical smoke or fire.

9. The pilot's radio transmissions and continued secondary radar coverage indicate that the pilot operated the aircraft's electrical system for at least three minutes after experiencing smoke in the cockpit.

10. Immediate isolation of the electrical fault likely would have reduced the speed with which the smoke or fire progressed.

11. The aircraft was not equipped with smoke goggles or an oxygen system, nor were they required by regulation.

Causes and Contributing Factors

The aircraft went out of control following incapacitation of the pilot by heavy smoke in the cockpit. The smoke and subsequent fire were likely caused by heat generated by a mechanical fault associated with the avionics relay. A contributing factor that likely aided in the progression of the fire was the continued operation of the aircraft's electrical system after the smoke was reported.

Safety Action

Action Taken

1. The operator has amended the company recurrent pilot training curriculum to incorporate additional issues relating to equipment serviceability and reporting, electrical failure, and smoke and fire.

2. Transport Canada indicated that they would undertake the following action:

   a) The operator will be made aware of its responsibility to ensure that any maintenance carried out on its aircraft must be performed in accordance with national regulatory standards. A review of its quality assurance policies regarding repairs and modifications will also be performed.

   b) Other aircraft operating in Perimeter Aviation's fleet will be reviewed to determine if there have been any other unapproved or undocumented modifications performed on those aircraft.

This report concludes the Transportation Safety Board's investigation into this occurrence. Consequently, the Board, consisting of Chairperson Benoît Bouchard, and members Maurice Harquail, Charles Simpson and W.A. Tadros, authorized the release of this report on 14 August, 1997.