Transportation Safety Board of Canada
Bureau de la sécurité des transports du Canada

AVIATION INVESTIGATION REPORT
A09Q0181

FUEL STARVATION

PIPER PA-34-200T C-FANI
MIRABEL, QUEBEC
11 OCTOBER 2009

Canada

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

Aviation Investigation Report

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Summary

The privately operated Piper PA-34-200T (registration C-FANI, serial number 34-7570278) took off from Saint-Georges Airport, Quebec, and was headed for Gatineau, Quebec, on an instrument flight plan. The aircraft was in cruising flight at an altitude of 10,000 feet and was 7.4 nautical miles (nm) southwest of Mirabel Airport, Quebec, when both engines simultaneously lost power. The aircraft entered a 180° right turn. The pilot informed air traffic control that he was having engine problems but did not declare an emergency. Radar vectoring was provided to the pilot to direct him to Mirabel Airport. During the descent, the aircraft deviated southward before turning back toward the airport. The aircraft could not glide to the airport with the remaining altitude, and it crashed in a maple bush 1.2 nm from the threshold of Mirabel Airport Runway 06 at 1732 eastern daylight time. The aircraft was located by a helicopter several minutes later. The pilot, who was the only person on board, was seriously injured.

Ce rapport est également disponible en français.

Other Factual Information

Pilot

The pilot held a private pilot licence and was qualified for the flight in accordance with existing regulations. He had a total of over 4800 flying hours, including 3800 on the PA-34.

Weather Conditions

The weather conditions reported at Mirabel Airport at 1700 hours[1] were as follows: cloud consisting of scattered stratocumulus at 6000 feet above ground level (agl), broken altocumulus at 9000 feet agl, wind 220° true at 10 knots, and occasional light rain showers. The activity resulting from the crash delayed the broadcast of the routine 1800-hour weather report until 1817. At that time, the cloud layer was composed of scattered altocumulus at 8000 feet agl and the wind was 280° true at 5 knots.

Aircraft

The twin-engine Piper Seneca PA34-200T was maintained in accordance with existing regulations and had the required equipment for instrument flight. The instrumentation had been modernized and featured a primary flight display and a three-axis autopilot system connected to the global positioning system (GPS). A fuel flow meter for calculating the fuel used had also been added. At the time of the accident, the aircraft logbook contained no deferred maintenance items. The aircraft's weight and centre of gravity were within the prescribed limits.

History of the Flight

The day before the accident, the fuel tanks were filled with 258 L of fuel, and the aircraft was stored in a hangar belonging to the pilot. The next day, the pilot realized that he had to return to Gatineau. He arrived at the hangar at the same time as an employee scheduled to wash the aircraft.

The pilot initialized the fuel flow indicator system by entering the value corresponding to a full tank (176 L per tank). The aircraft departed around 1612 and reached a cruising altitude of 10,000 feet above sea level (asl) at 1627. The expected duration of the flight was 1 hour and 35 minutes, and the fuel autonomy for full tanks is just over 4 hours. During the flight, fuel management was limited to checking the fuel flow to each engine and the remaining quantity of fuel, which is indicated digitally by the system. Little attention was paid to the fuel gauges because they are imprecise.

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1 All times are eastern daylight time (Coordinated Universal Time minus four hours).

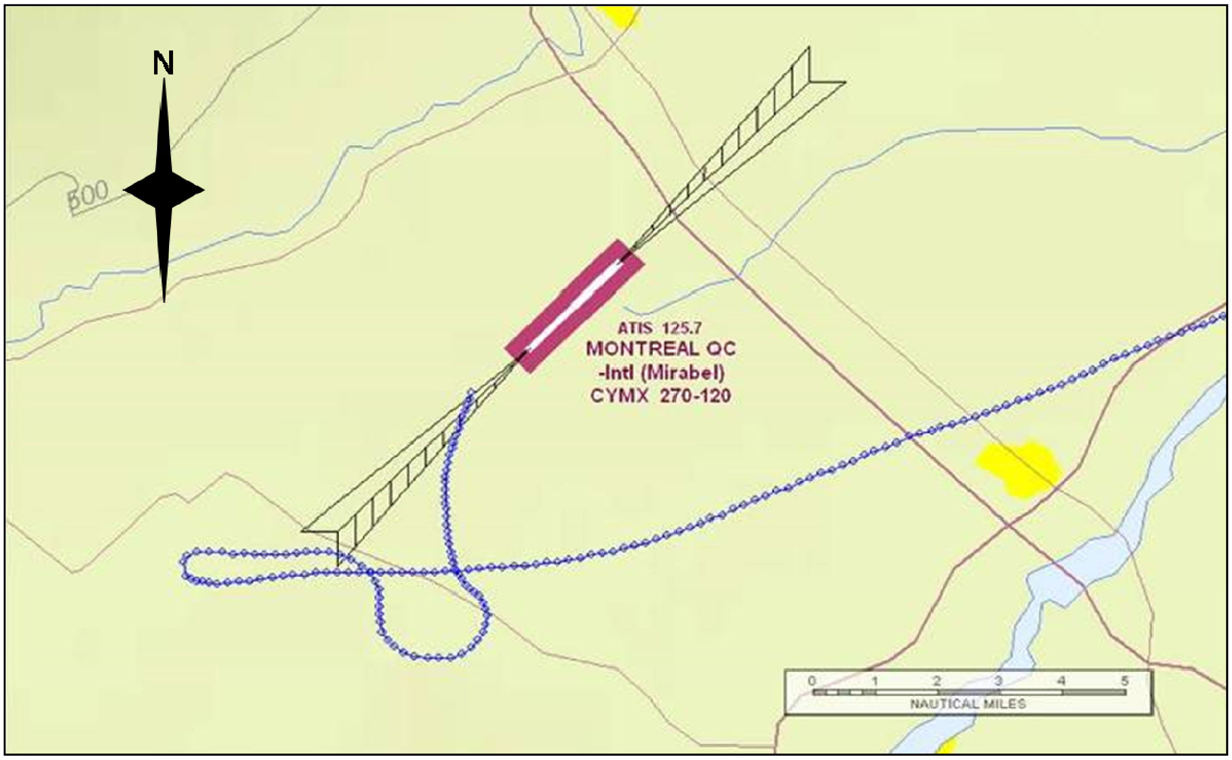

Figure 1. Trajectory of the aircraft

At 1726, 1 hour and 14 minutes into the flight, the aircraft was 7.4 nm southwest of Mirabel Airport when both engines lost power. The autopilot disengaged and the aircraft entered a right turn of approximately 180°. (See Figure 1.) After the turn was made, the aircraft was 1000 feet below its assigned altitude, and the pilot informed air traffic control (ATC) that he was having engine problems but did not declare an emergency. He said that the engines seemed frozen. He was assigned a heading of 080º magnetic to direct him toward Mirabel Airport. ATC asked whether he would need emergency equipment at Mirabel or whether he would like to declare an emergency. The pilot declined. He read back the heading of 080º but continued to turn south on a heading of approximately 180º magnetic before being assigned a new heading toward Mirabel. Once the pilot stated that he had visual contact with the runway, ATC cleared him for a visual approach to Runway 24, because the ground-level wind of 6 knots favoured landing on that runway. At approximately 4500 feet asl, the pilot reported that the engines were still running, even though the engines were not developing any power. During the descent, the pilot activated the booster pumps, but to no avail. The propellers were not feathered and continued to windmill. At 1600 feet asl, 2.2 nm west of the Runway 06 threshold, the pilot advised Mirabel Radio that he could not make it to Runway 24. The aircraft disappeared from the radar screen at approximately 400 feet asl (150 feet agl) and crashed at 1732 hours, 1.2 nm from the threshold of Mirabel Airport Runway 06.

Impact

The aircraft crashed in a maple bush among mature trees measuring an average of 24 in. in diameter and over 100 feet tall. The aircraft penetrated the trees on a heading of 040º magnetic, with a right bank angle of approximately 30°.

Figure 2. View of the aircraft

The right fuel tank was perforated in the impact, and the left fuel tank was completely gutted. The fuselage came to rest on its back against a tree measuring approximately 8 in. in diameter that penetrated the cabin on the passenger side (see Figure 2). A strong odour of fuel was present at the crash site, confirming that there was fuel on board at the time of impact. The pilot was seriously injured. He managed to exit the cockpit and was found in the rear cabin.

Rescue

Although the pilot did not declare an emergency, the flight service specialist on duty at Mirabel told the airport's Aircraft Rescue and Fire Fighting (ARFF) crew to be ready to respond because an aircraft in distress was heading toward the airport. Following the impact, the specialist advised ARFF that the crash site was approximately half a mile south of the Runway 29 threshold but could not confirm whether the site was inside the airport perimeter. ARFF immediately notified the Sûreté du Québec and firefighters from the municipality of Mirabel. Because locating the aircraft would be difficult, the specialist asked a Bell 222 helicopter crew returning to Mirabel from Montreal to help pinpoint the crash site. After identifying the crash site, the helicopter landed in a neighbouring field. The helicopter co-pilot walked through the bush toward the site with guidance from the helicopter, which had taken off again and was hovering over the wreckage. The helicopter co-pilot arrived at the site at 1756 and observed that the pilot of the accident aircraft was injured but conscious. Because getting to the site was difficult, it was not until 1815 that one of the firefighters was able to administer first aid to the injured pilot.

The helicopter was not configured to transport a patient lying down, so the pilot of the accident aircraft was finally evacuated in a 4×4 truck around 1900 hours with the assistance of the owner of the maple bush, who knew of a logging road adjacent to the site.

Fuel system

The fuel system for this aircraft consists of two cells, one in each wing, that are connected to form a single tank (see Appendix A). The tanks are shaped to fit the space inside the wings, and because their surface area is so large compared to their depth, a difference of a few millimetres in the fuel level can represent several litres of fuel. Each tank can hold 46.5 US gallons of fuel, 2.5 of which are unusable, leaving 44 gallons (166.5 L) of usable fuel.

Figure 3. Fuel selector

The fuel system has two fuel selectors (see Figure 3), one for each engine, which are identified as LEFT ENGINE and RIGHT ENGINE. Each selector has three positions. The forward position (ON) enables each tank to fuel its respective engine. The central position (OFF) cuts off the fuel supply. The rear position (XFEED) is for crossfeeding, or fuelling an engine from the opposite tank. In other words, if the right fuel selector is on XFEED, the right engine will receive fuel from the left tank.

According to the pilot's checklist, the operation of the fuel selectors is checked while the aircraft is taxiing. In this occurrence, the operation was checked before the aircraft had started to taxi. To check the operation of the fuel selectors, the pilot sets one of the selectors to OFF. Once the corresponding engine starts cutting out, the selector is set to XFEED, and then the engine should resume operating normally. Then the selector is set to ON. The selector for the other engine is checked in the same manner. The checklist then provides four other opportunities to ensure that the two fuel selectors are set to ON: on run-up, during pre-takeoff checks, when the aircraft is lining up on the runway, and once the aircraft is established at cruising altitude. When the aircraft was examined at the crash site, the left selector was set to ON and the right to XFEED.

A note in the aircraft flight manual indicates that each engine returns vapours and a percentage of fuel to its respective tank. Because of this, at least 30 minutes of fuel from that tank must be used before selecting crossfeed mode. If the fuel gauge indicates that the tank is nearly full, the fuel in that tank must be used for 30 additional minutes to lower the level of fuel in the tank; otherwise the fuel will be drained via the tank vent.

Examination of the specifications for the Teledyne Continental TSIO-360-EB and LTSIO-360-EB engines installed in the subject aircraft revealed that each engine can return a maximum of 80 lb of fuel per hour to its respective tank when operating at full throttle. No specifications are provided for lower RPMs, as in cruising or descending throttle settings. The rate of fuel return does not depend on the power used; rather, it is related to engine RPM. Since the RPM of the fuel pump in the fuel regulator is proportionate to that of the engine, the rate of fuel return decreases with a reduction in engine speed. The volume of a given weight of fuel varies with temperature; at 15°C, 80 lb of fuel has a volume of 50.47 L.

A fuel consumption calculation shows that, during the 15-minute climb with an average fuel consumption of 45 L/h per engine, each engine consumed 11.25 L of fuel. During 59 minutes of cruising at 40 L/h per engine, each engine consumed 39.33 L of fuel. This gives a total of 50.58 L used by each engine, or 101.16 L for both engines.

The aircraft used a Janitrol heater that consumes 3 L of fuel per hour, so it consumed 3.7 L of fuel during the 1 hour 14 minute flight.

Using fuel return quantities corresponding to the reduction in engine speed (50 L while climbing and 45 L while cruising), an estimated 56.75 L of fuel would have been returned to the right tank and drained via the vent. This situation would not occur unless the right selector was set to XFEED for the whole flight (the position in which it was found at the crash site).

The total fuel consumed by the engines (101.16 L), plus the heater's fuel consumption (3.7 L), plus 56.75 L of fuel returned to the right tank, yields a total of 161.61 L. This is less than 5 L below the 166.5 L of usable fuel in each tank.

The addition of a digital system that displays the rate of fuel consumption allows the pilot to see the quantity of fuel used by each engine. However, the sensor is installed downstream from the fuel regulator and measures only the fuel fed to the injectors. The system also includes a fuel meter. The fuel meter subtracts the quantity of fuel consumed by the engine from the quantity in the tank as indicated on departure, without taking into account the source of the fuel or the quantity left in the tanks. The system proved reliable with use, indicating the exact quantity of fuel required when refuelling, thereby leading the pilot to pay more attention to it than to the fuel gauges.

Engine failure

The pilot had done numerous engine failure drills. However, he did not do any drills for the simultaneous failure of both engines; there was no requirement to do so. The probability of a simultaneous mechanical failure of both engines is very low. Moreover, the aircraft manufacturer has not published any procedures for a simultaneous failure of both engines. However, when engine failure occurs, the first item on the pilot's checklist, after ensuring that there is no engine fire, is to set the fuel selector to ON or XFEED.

When the engine failure occurred, the aircraft was 6.5 nm from the Runway 06 threshold and then continued to within 4.5 nm of the runway threshold before deviating south. The deviation increased the distance required to reach the threshold. The aircraft glided 10.7 nm before crashing.

Emergency Locator Transmitter

The aircraft was equipped with an emergency locator transmitter (ELT) that transmits on 121.5 MHz and 406 MHz. The ELT was not damaged in the crash and was activated by the impact. However, the antenna mounted on the back of the cabin was broken in the impact and made it difficult to capture signals.

This ELT is programmed to transmit a coded message 50 seconds after impact that allows the Canadian Mission Control Centre (CMCC) to access the information provided when the ELT is registered, including the aircraft identification and the person or organization responsible for the aircraft. This message is normally received on 406 MHz by a GEO satellite.[2] However, unless the ELT is capable of transmitting a GPS position, which was not the case for the model installed on the C-FANI, the satellites can only identify the ELT sending the signal and cannot provide information on its position. The CMCC states that, because the satellites are positioned so high above the Earth, if the antenna is damaged or covered by the wreckage after the accident, the coded message cannot be captured. However, another type of satellite, the LEO,[3] can capture the coded message on 406 MHz and fix the position of the signal. Even if the antenna is damaged or poorly oriented, LEO satellites can sometimes receive a signal and identify its location, as was the case in this situation.

As of 1 February 2009, the international search and rescue satellite network COSPAS-SARSAT[4] no longer receives signals transmitted at 121.5 MHz. However, these signals may be captured by aircraft monitoring this frequency. After the crash, no aircraft reported receiving a signal on 121.5 MHz.

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[2] A satellite in geostationary orbit that is positioned approximately 35,800 km directly over the equator and orbits at the same rate as the Earth's rotation.

[3] LEO stands for Low Earth Orbiting satellite. It is called "low-orbiting" because it revolves around the Earth at a height of 1000 km. It takes approximately two hours to orbit the Earth. This means it is within range of equipment on Earth for only a few minutes. Because this type of satellite is relatively close, it can work with much smaller transmitting equipment, e.g., a very small antenna.

[4] COSPAS is the space-based system that searches for vessels in distress, and SARSAT stands for Search And Rescue Satellite-Aided Tracking.

The accident occurred at 1732. ATC transmitted the information to search and rescue (SAR) services at 1755. Since there are sometimes no LEO satellites in place to capture a signal, delays of up to two hours can occur.

In this occurrence, the first alert with the coded information sent to CMCC via satellite was received at 1802, 30 minutes after the crash. The signal transmitted two positions, one being a ghost position. On the second satellite pass, the actual position stayed the same and the ghost position changed. The second pass was reported at 1909 and provided a position less than 1000 feet from the crash site. The signal can be captured by more than one satellite at a time, and a total of 18 signal captures were recorded. The coordinates provided by each capture were different but were less than half a mile from the crash site. The last transmission was received at 0231 the next day.

The ELT shut off around 0915. It was designed to transmit for at least 24 hours. No transmissions were received 9 hours after the ELT was activated.

The TSB Engineering Branch Laboratory examined the ELT and determined that it was capable of transmission on both frequencies and that the battery had enough power to generate a 5-watt signal, which met requirements. The broken antenna made it difficult to capture the signal.

Analysis

The most plausible hypothesis is that the right fuel selector was left on XFEED after being checked prior to the aircraft's departure from Saint-Georges.

The fuel consumption calculation shows that, in such a case, the flight would have had 166.5 L of fuel available for 74 minutes of flight before the engines stopped, equivalent to an hourly consumption of 135 L, which is much higher than the usual consumption of 80 L/h. The difference of 55 L was therefore returned to the right tank. Since the right tank was full, this fuel was drained via the vent.

When the aircraft is being fuelled, the large surface area of the tanks means that a difference in fuel level of a few millimetres represents several litres, rendering the 5 L discrepancy between the fuel available and the fuel used negligible. In addition, the exact rate of consumption and the precise departure time could not be validated. The simultaneous stopping of the engines, the position in which the right selector was found and the fuel consumption calculation confirm that the double engine failure resulted from both engines being fed from the same tank.

When departing from Saint-Georges, the pilot may have been distracted by the employee who greeted him while he was doing his pre-flight checks, and he may have forgot to return the right fuel selector to ON. However, the checklist provides four opportunities to ensure that both fuel selectors are set to ON: on run-up, during pre-takeoff checks, while lining up on the runway and once established at cruising altitude. The pilot did not correct the selector position, which suggests that the checklist was not used.

Since the pilot did not pay close attention to the fuel gauges while in flight, he did not realize that the left tank was being depleted rapidly while the right tank remained full. Because the autopilot was on, the pilot could not feel the lateral imbalance in the controls that was caused by the difference in the quantities of fuel in each tank. The imbalance explains why the aircraft turned to the right once the autopilot disengaged. The pilot's workload suddenly increased and he did not realize that the aircraft was turning.

The primary duty of a pilot is to manage flight-related risks effectively. Checklists are the most readily available means of defence against threats, errors and undesirable conditions. The omission of items on the checklist on run-up, during pre-takeoff checks, while lining up on the runway, once established at cruising altitude, and following the loss of power, gradually increased the risk, up until the crash.

The digital fuel consumption system operated normally. Each tank contained 166.5 L of usable fuel, but the system had been programmed to indicate the total per-tank capacity of 176 L when it was re-initialized before the aircraft departed Saint-Georges. Since the system was not designed to detect the fuel remaining in the tanks, the system would have indicated approximately 125 L per tank (176 minus 50.58) at the time when the engines lost power, because it took into account only the fuel consumed by the engine. Its customarily reliable readings led the pilot to not wonder how much fuel was left in the tanks after the engines lost power. In the absence of yawing, the pilot did not identify the loss of power as an engine failure, and the emergency checklist for the loss of one engine was not followed.

Because the propellers were not feathered, they were windmilling, which gave the pilot the impression that the engines were still running, albeit slowly. This could explain why the pilot told ATC that the engines were still running as he descended through 4500 feet. Setting the left selector to XFEED and the right selector to ON would have restored the fuel supply to both engines.

When the engines stopped, the aircraft was at 10,000 feet asl and 6.5 nm from the Runway 06 threshold. Considering that the aircraft's deviation to the south increased the distance to be travelled by 4.2 nm and that the aircraft crashed 1.2 nm from the threshold, it is highly likely that the aircraft could have glided all the way to the Runway 06 threshold, even though the propellers had not been feathered.

Despite the obvious lack of power, the pilot chose not to declare an emergency. Declaring an emergency at the right time allows pilots to benefit from immediate, sustained attention from ATC and better assistance when they face an emergency or an abnormal situation. Any deviation from the instructions provided, such as straying off an assigned heading, is immediately indicated to the pilot in order to provide the best possible assistance.

The ELT was capable of transmitting on 121.5 and 406 MHz, and the battery had enough power to generate a signal. However, the broken antenna made it difficult to capture signals.

Although locating the aircraft was facilitated with the assistance of a passing helicopter, reaching the site proved difficult. The delay of 1 hour and 30 minutes between the crash and the evacuation of the injured pilot was due to the crash occurring outside the airport perimeter in a private maple bush, access to which was not well known except by the owners.

Findings as to Causes and Contributing Factors

1. The right fuel selector was left in the XFEED position, probably because the pilot was distracted and/or failed to follow the checklist. As a result, both engines were being fuelled by the left tank until it was completely empty, causing both engines to fail simultaneously.

2. The pilot relied on a fuel quantity indicator system that was based on the engine's fuel consumption and not on the quantity of fuel remaining indicated by the gauges.

3. The pilot did not recognize the loss of power as being an engine failure. The emergency checklist for engine failure was not followed.

Other Findings

1. The aircraft's emergency locator transmitter (ELT) broadcast signals at 121.5 MHz and 406 MHz. It was not damaged on impact, but the antenna was broken, making it difficult to capture signals.

2. The pilot did not declare an emergency and did not clearly indicate the nature of the problem. Therefore air traffic control (ATC) could not anticipate his needs.

This report concludes the Transportation Safety Board's investigation into this occurrence. Consequently, the Board authorized the release of this report on 29 April 2010.

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