Transportation Safety Board of Canada

Bureau de la sécurité des transports du Canada

AVIATION INVESTIGATION REPORT
A09C0167

FUEL STARVATION AND FORCED LANDING

WEST CARIBOU AIR SERVICE INC.
CESSNA 185A C-FBWP
THUNDER BAY, ONTARIO, 10 nm NE
23 OCTOBER 2009

Canada

Aviation Investigation Report

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Summary

The West Caribou Air Service Inc. float-equipped Cessna 185A (registration C-FBWP, serial number 185-0430) departed Summer Beaver, with one pilot and one passenger on board for a visual flight rules flight to Thunder Bay, Ontario. Approaching Thunder Bay, the pilot orbited while attempting to contact the control tower. During a gradual right turn, the engine lost power and the pilot was forced to land into trees approximately 10 nautical miles northeast of Thunder Bay. The pilot and passenger were not injured, but the aircraft was substantially damaged. The accident occurred during daylight hours at 1458 Eastern Daylight Time.

Ce rapport est également disponible en français.

Other Factual Information

Weather

The 1500 [1] aviation routine weather report (METAR) for the Thunder Bay Airport was as follows: wind 060° True (T) at 10 knots, visibility 20 statute miles (sm), temperature 3°C, overcast cloud at 1400 feet above ground level (agl), altimeter setting 29.83 inches of mercury. Forecast upper winds for 3000 feet above sea level (asl) valid for use between 0500 and 1400 for Big Trout Lake [2] were 210°T at 12 knots and for Armstrong, [3] were 140°T at 12 knots. The effect of these winds would have been a 10-knot headwind component for both an earlier flight between Webequie and Summer Beaver and the occurrence flight between Summer Beaver and Thunder Bay.

Pilot Qualifications

The pilot held a commercial pilot licence valid for single-engine land and sea aeroplanes, with night and class IV instructor ratings, and a category 1 medical certificate valid until 01 July 2010. The pilot graduated from an aviation college training program in the spring of 2009 and was hired by the company in September 2009. Available records indicate that the pilot had accumulated approximately 450 hours of total flight time prior to the occurrence with approximately 33 hours on the accident aircraft.

Company Training

The pilot underwent a company training program that included dangerous goods and company policy training, as well as flight training and emergency procedures on the Cessna 185 and Norseman aircraft types.

The West Caribou Air Service Inc. company operations manual (COM) requires a minimum of three hours of initial flight training for each aircraft type a pilot flies. [4] This requirement is consistent with the Commercial Air Services Standards (CASS). [5]

For day VFR operations, the CASS requires the chief pilot or delegate to certify the competency of each pilot on the most complex single-engine aeroplane to be flown. The regulations require only that pilots be certified as competent, and do not require that a separate competency check flight be conducted in addition to any training flights. Therefore, the minimum 3.0 hours of initial flight training requirement may include flight time during a pilot competency check.

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1 All times are Eastern daylight time (coordinated universal time minus four hours).

2 Big Trout Lake is located 83 nm northwest of Summer Beaver.

3 Armstrong is located 120 nm north of Thunder Bay, on the flight path between Summer Beaver and Thunder Bay.

4 COM, Chapter 6, annex A, paragraph 3.

5 CASS 723.98, table 1.

The investigation examined company training files, aircraft journey logs, and the occurrence pilot's flying log. The training pilot's flying log had not been kept up to date, and provided no documentation of any of the occurrence pilot's training flights. The records examined contained the following information regarding the pilot's Cessna 185 flight training:

- On 19 September 2009, the pilot received 0.5 hours, according to the aircraft journey log and the pilot's flying log. However, the flight was not recorded in the company training file.

- On 04 October 2009, the pilot received 1.5 hours, and also flew a 1.0 hour pilot competency check. While these flights were recorded in the company training files and the training pilot certified the pilot as qualified for assigned flight duties, they were not recorded in the aircraft journey log or the pilot's flying log.

- On 05 October 2009, the pilot received an additional 1.9 hours of training during line operations, according to the aircraft journey log and the pilot's flying log. These flights were not recorded in the training file. The company operational flight plan and manifest for these flights show they carried passengers and cargo.

The COM specifies that, "only flight crew essential to the training shall be carried on board or other company personnel for familiarization purposes during a training flight."

The COM chapter 6, annex A, paragraph 2 requires six hours of technical ground training to ensure each flight crew member is knowledgeable with respect to aircraft systems and all normal, abnormal, and emergency procedures. The pilot had not received any classroom training, but had been provided a copy of the Cessna 185 aircraft owner's manual for self-study. The training file indicates the pilot completed Cessna 185 technical ground training during the period 19 September to 04 October 2009, but did not include any record of how much training was provided.

Pre-Flight Preparations

The aircraft was stationed at the company's float plane base in Webequie. On the evening prior to the occurrence the pilot was informed that a passenger was to be picked up in Summer Beaver at noon and flown to the water aerodrome in Thunder Bay. The acting chief pilot instructed the pilot to fill the aircraft with fuel, but did not provide explicit instructions on how to do so or specify which fuel filler openings were to be used. The acting chief pilot estimated that the flight would be between 3 and 3.5 hours and that a full fuel load would ensure 4.5 hours of endurance plus 0.5 hours of reserve. This estimate was based on the aircraft's full fuel capacity of 84 US gallons and a full rich mixture fuel consumption of 16 US gallons per hour (gph).

The aircraft was equipped with Wipline model 3700 floats, for which cruise performance charts are not available. The Cessna 185 Floatplane owner's manual supplement for aircraft equipped with EDO Model floats provides a cruise performance chart for various altitudes, based on a normal lean mixture. No figures are available for operation on a full rich mixture. The specified

endurance at 2500 feet asl at 70 per cent power (24 inches manifold pressure (mp) and 2450 rpm), with no allowance for reserve fuel, is 5.5 hours with 81 US gallons usable fuel and 4.2 hours with 62 US gallons of usable fuel.

On the day of the occurrence, the pilot prepared and fuelled the aircraft from the company's fuelling facility. The aircraft was equipped with an early model ON-OFF fuel system with long range tanks. [6] Fuel is contained in bladder style wing tanks (one in each wing) equipped with inboard and outboard fuel filler openings. Filling the tanks through the inboard fuel filler openings provides a total fuel capacity of 65 US gallons of fuel (of which 62 US gallons are usable); filling through the outboard fuel filler openings provides a total fuel capacity of 84 US gallons (of which 81 US gallons are usable). The manufacturer had incorporated the inboard fuel filler opening for float-equipped aircraft to facilitate fuelling from a step on the fuselage.

The pilot filled the fuel tanks using the inboard fuel filler openings and used a dip stick to confirm a fuel load of 32.5 US gallons per side. The pilot had never used the outboard fuel filler openings during his brief time with the company or during flight training at the aviation college on a similar type float-equipped aircraft. During the company training program the pilot was instructed that a full fuel load would provide 4.5 hours of endurance. The pilot believed that this was based on use of the inboard fuel filler openings and an average fuel consumption rate of 15 US gph at a cruise power setting of 24 inches mp and 2450 rpm. Based on a direct distance of approximately 350 nm and an average groundspeed of 120 miles per hour (mph), the pilot estimated the total flight time from Webequie to Summer Beaver to Thunder Bay to be about 2.5 to 3.0 hours with a total fuel burn of approximately 38 US gallons.

The aircraft fuel gauges had been reading intermittently prior to the accident and were not monitored by the pilot during flight. The gauges would sometimes read empty when the tanks were full, but the fault could not be duplicated during maintenance troubleshooting. The pilot was instructed to dip the fuel tanks prior to each flight to assess the quantity of fuel on board, and to use fuel calculations to ensure an adequate fuel supply for the flight.

History of Flight

The aircraft left the dock in Webequie at 1037 and taxied to the north end of the lake. The pilot conducted the normal pre-flight engine run and checks prior to taking off into wind towards the south. The pilot turned west towards Summer Beaver and climbed to a cruising altitude of 2000 feet asl. The pilot selected a full-rich mixture setting in accordance with company policy on flights below 5000 feet asl. The company policy was introduced to prevent high engine temperatures resulting from excessive leaning of the engine fuel mixture at lower altitudes, which could cause damage to the engine cylinders and valves. Upon reaching Summer Beaver, the pilot circled the town, observed ice on a portion of the lake, and landed on an ice-free area some distance from the float base, arriving at the dock at 1125.

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[6] See Appendix A – Fuel System Diagram.

The passenger arrived at the dock with more baggage than expected, and the rear seats were removed and stowed to make more room. There was no scale at Summer Beaver and the pilot estimated the weight of each piece of baggage. The baggage was placed in the cabin area behind the cockpit seats. There was no cargo net; ropes were available, but were not used. The aircraft's total weight was estimated at 3310 pounds, which is the maximum authorized gross weight.

The aircraft departed Summer Beaver at 1203. The aircraft climbed to a cruising altitude of 4500 feet asl. At the full rich-mixture setting, the fuel flow gauge indicated about 16.5 to 17 US gph and the aircraft's groundspeed varied between 110 and 120 mph, as displayed by the onboard global positioning system (GPS). At 1450 the pilot advised the Thunder Bay tower controller that the aircraft was 15 miles north of the airport and would be landing at the Thunder Bay water aerodrome in 6 minutes. The tower instructed the pilot to report on final approach to the harbour. The pilot could not understand the controller's communications as the radio reception was poor.

Not knowing whether he was cleared to enter the control zone or not, the pilot began a shallow turn to the right [7] to avoid entering controlled airspace without clearance. He then repeated his arrival intentions to the tower. Approximately 3 minutes into the turn at 3000 feet asl (1700 feet agl), the engine began to sputter and lose power. The aircraft wings were levelled and the pilot performed the engine power-loss check from memory. The engine mixture was confirmed full rich, with the magnetos set to BOTH. The engine throttle was pumped, but the engine did not respond. The electric auxiliary fuel pump, which was required by the owner's manual to be activated in the event of engine failure during flight, was not turned ON.

The pilot informed the tower that the aircraft was out of fuel and no further communications were exchanged. The aircraft banked left towards a small lake that lay back along the flight path, but the aircraft was too low to reach the lake. The aircraft rolled out of the left bank and the pilot slowed the aircraft just prior to entering the trees. The aircraft came to rest in a left wing low, nose-down attitude at the base of a large tree. Both wings and floats were substantially damaged and both cockpit doors were jammed shut. The baggage had shifted, but had not come into the cockpit. The pilot and passenger were uninjured and were able to exit the aircraft through the right cockpit door window.

The aircraft was equipped with a newly-installed 406 MHz emergency locator transmitter (ELT) and a SPOT™ satellite device. The company had been tracking the progress of the flight using the SPOT system. At 1515 the pilot activated the SOS/911 button on the unit which alerted the company (through the SPOT emergency response center) of the accident. Using a satellite telephone, the pilot contacted the company and guided the rescuers to the site. The Department of National Defence, Joint Rescue Coordination Center (JRCC) in Trenton, Ontario, picked up the ELT signal and initiated a search. JRCC contacted the Winnipeg area control center, the company and the Ontario Provincial Police, and assisted in the coordination of the rescue operations. Rescuers arrived at the site about 1605.

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[7] See Appendix B – Aircraft Flight Path.

Aircraft Fuel System

The fuel tanks are connected by a crossover vent line and vented overboard through a line on the lower surface of each wing (see Appendix A). Sloshing of fuel into the crossover vent line can cause unequal pressure in the tanks, resulting in uneven draining of fuel and fuel imbalance.

A float-type fuel sending unit is mounted in each tank which connects to a fuel quantity gauge on the instrument panel. The aircraft is not equipped with a low-fuel warning system or light. Fuel flows by gravity from each wing tank through fuel supply lines at the forward and aft lower inboard corners of the tank. The fuel supply lines connect to an accumulator tank mounted under the instrument panel on the engine firewall. Fuel from the accumulator tank flows through a fuel shut-off valve, a fuel strainer, and a by-pass in the electric auxiliary fuel pump (when it is not operating) to the engine-driven fuel pump. The electric auxiliary fuel pump is a two-speed HI and LO position pump normally used for engine start or for vapour purging. The HI position is intended for use in an emergency situation if the engine experiences a loss of power.

Site Examination

The left fuel tank vent line was draining fuel after the accident and had been plugged by the first responders. Later, the plug was removed by Transportation Safety Board investigators to determine the presence of fuel; a steady flow of fuel was observed. The left wing outboard fuel filler cap was also removed and fuel poured out of the opening. The right wing fuel tank was examined and no fuel was found. No fuel staining was evident on either wing surface. The fuel accumulator tank was drained and found to contain 13 ounces of fuel. The normal capacity is 115 ounces. The fuel supply lines at the fuel control unit and manifold valve were opened and found to contain no fuel. The fuel system was found to be intact with no breaches evident that would account for a loss of fuel. During the recovery of the aircraft an estimated 5 to 10 US gallons of fuel was found remaining in the left wing tank. The 300-horsepower Teledyne Continental IO-520-D engine was examined; no internal failures were identified and spark was evident on both magnetos. The engine-driven fuel pump and the Garmin *GPSmap 296* were removed for further examination. The weight of the aircraft baggage was estimated to be approximately 60 pounds less than the weight entered onto the flight manifest sheet. It was determined that the aircraft had been operating within its approved weight and balance limits.

Component Testing and Examination

The engine-driven fuel pump was taken to an engine overhaul facility for further examination. No anomalies were found that would have contributed to the loss of engine power. During the testing, it was noted that the engine-driven fuel pump is not self priming and requires fuel boost pressure to prime.

The GPS was sent to the TSB Laboratory in Ottawa. The data recovered from the GPS provided detailed information for all phases of operation for both flights, and indicated that the aircraft had been operating for 3 hours and 42 minutes at the time of the loss of power. The average ground speed for the cruise portion of the flight between Summer Beaver and Thunder Bay was

113 mph. Fuel consumption for each phase of flight was calculated using the low and high ends of the fuel flow ranges as experienced by West Caribou Air Service with the occurrence aircraft. The calculations indicate that the aircraft would have had between 2.5 and 8.4 US gallons of useable fuel remaining at the time of the engine power loss.

Aircraft Maintenance History

The aircraft had recently undergone major repair work and painting and was put back into service on 15 June 2009. Part of the work included the replacement of the right fuel tank, the installation of two new fuel sending units and a new radio installation. The new tank was installed in the same configuration as the old one.After the installation of the new fuel sending units, a fuel calibration test was carried out and the gauges operated normally. The approved manufacturing organization contracted out the installation of the new radio to an avionics facility.

The aircraft underwent a 100-hour inspection on 26 August 2009 and a 50-hour inspection on 08 October 2009. During that time period the fuel gauges were reported to be reading intermittently. When tested, however, the fault could not be duplicated and no repairs were carried out. The defect was not recorded in the aircraft logs.

Analysis

The pilot's licence and medical certificate were appropriate for the intended operation in accordance with existing regulations.

The training records and log book entries did not agree and were incomplete. Therefore, the investigation could not determine whether the pilot's company Cessna 185 flight and ground training met the minimum requirements specified in the COM and CASS for pilot competency certification. The flights on 05 October occurred after the pilot's competency certification, and also carried passengers and cargo, contrary to the company's policy on training flights; consequently they were not included in the TSB calculation of the amount of Cessna 185 flight training the pilot received.

During the briefing with the acting chief pilot the night before the occurrence, the pilot was told to fill the aircraft, but no instructions were provided as to which fuel filler openings to use. The acting chief pilot's intent was to have the pilot fill the fuel tanks with 84 US gallons of fuel to provide sufficient fuel for the flight plus reserves; however, the instructions to the pilot were not explicit and were misunderstood.

For ease of fuelling, the manufacturer provides an inboard fuel filler opening on float-equipped Cessna 185 aircraft equipped with the long range tank option. The pilot had never filled the tanks using the outboard filler openings, either during initial training or operation. The pilot believed that, for float operations, the term "full fuel" was used to describe a fuel load using the inboard fuel filler openings, and as a result, the aircraft departed with less than full fuel.

The pilot believed that the aircraft's 4.5 hours of endurance was based on use of the inboard fuel filler openings providing 65 US gallons fuel capacity with an average fuel flow of 15 gph. His pre-flight estimates of flight time (2.5 to 3.0 hours) and fuel consumption (38 US gallons) were based on an average fuel flow of 15 gph, a groundspeed of 120 mph, and direct distance between departure and arrival points. No allowance was made for the 3 US gallons of unusable fuel, or for additional fuel consumed during engine start, taxi, engine run-up, takeoff, climb, or manoeuvring during departure and arrival. Additionally, the pilot did not consider the possibility of lower than expected groundspeed due to headwinds, or higher than expected fuel flow, and no allowance was made for these contingencies.

The recorded GPS data revealed that, because the groundspeed was lower than the pilot had planned and some departure and arrival manoeuvring was required, the total aircraft operating time was 3 hours and 42 minutes (3.7 hours). Approximately 6 additional minutes would have been required for the flight to reach the Thunder Bay harbour aerodrome, giving a total flight time from Webequie to Summer Beaver to Thunder Bay of 3.8 hours, or 48 minutes longer than the pilot had estimated during pre-flight planning. Additionally, because of the company's full-rich mixture policy, the fuel flow during the flights averaged 16.5 to 17 gph rather than the planned 15 gph. Consequently, the aircraft's fuel reserves were substantially depleted by the time the aircraft reached the Thunder Bay area.

The pilot had not been monitoring the fuel quantity gauges during flight due to an intermittent fuel gauge reading. The company was aware of the intermittent fuel gauge reading and asked maintenance personnel to fix the problem. Maintenance personnel could not duplicate the snag, and consequently no repairs were carried out. The company instructed the pilot to rely on his fuel calculations as a means to ensure sufficient fuel quantity and duration. Without an effective means of monitoring the actual fuel state in-flight, and with no low-fuel warning devices, the risk of an unexpected engine stoppage due to starvation or fuel exhaustion was increased.

After the engine power loss, the pilot contacted the Thunder Bay tower and indicated that the aircraft was out of fuel. This statement indicates that the pilot had some awareness of the aircraft's low fuel state, but probably did not know that fuel starvation was imminent. When he was unable to communicate with the tower, the pilot elected to extend the flight by circling rather than entering the control zone without clearance and heading direct to the water aerodrome.

A fuel imbalance could occur during flight due to unequal draining of the tanks, or movement of fuel from one tank to the other. No fuel was found in the right tank, indicating that the tank had emptied during flight.

The engine power loss occurred during the gradual right turn. With no fuel in the right tank, the fuel remaining in the left wing tank should have been sufficient to maintain engine power. During a coordinated right turn, the usable fuel in the left tank would be expected to feed normally. However, during a skidding right turn, the fuel would have moved outboard, away from one or both fuel supply line pickups in the left tank, leading to a reduction in flow to the accumulator tank. The engine fuel demands exceeded the amount of fuel entering the accumulator tank, reducing the fuel level to the point where there was insufficient fuel feed to keep the engine running.

When the engine lost power, the engine-driven fuel pump would have lost its prime. When the wings were levelled, fuel would have been gradually fed back into the accumulator tank, but, without prime, the engine-driven pump will not pump fuel. After the loss of engine power, the pilot performed the engine-out emergency procedures from memory, but did not turn on the electric auxiliary fuel pump. As a result the engine could not regain power.

During loading of the aircraft in Summer Beaver, the aircraft's baggage was placed in the cabin area, but was not properly secured. The baggage shifted during the crash, but did not enter the cockpit area. The unsecured baggage presented a risk of injury to the occupants during the crash.

The following TSB Laboratory report was completed:

LP 149/2009 – GPS Download

This report is available from the Transportation Safety Board of Canada upon request.

Findings as to Causes and Contributing Factors

1. It could not be established whether the pilot's company Cessna 185 training met the minimum requirements specified in the company operations manual (COM) and Commercial Air Services Standards (CASS) for pilot competency certification. The pilot's pre-flight fuel planning and response to the engine power loss are indications that his training did not sufficiently prepare him to perform his assigned duties.

2. The acting chief pilot and the occurrence pilot had different understandings of "full fuel" and the instruction to the pilot was not clearly communicated. As a result, although both the pilot and the company intended that the aircraft depart with full fuel, it departed with less than full fuel.

3. The pilot underestimated the en route flight time and overestimated the aircraft's endurance. The aircraft used more fuel than expected and its fuel reserves were substantially depleted.

4. The fuel gauges were not reliable and were not monitored during the flight; consequently, the pilot was not fully aware of the aircraft's in-flight fuel state.

5. An unequal quantity of fuel developed in the tanks as the flight progressed. The engine likely lost power as a result of fuel starvation when the small amount of fuel remaining in the left wing moved away from the fuel supply line pickups in the left tank during a gradual right turn.

6. After the engine lost power, the pilot did not turn on the electric auxiliary fuel pump, and as a result, engine power was not restored.

Finding as to Risk

1. During loading, the baggage was not secured in the cabin area. The baggage shifted during the crash, increasing the risk of injury to the occupants.

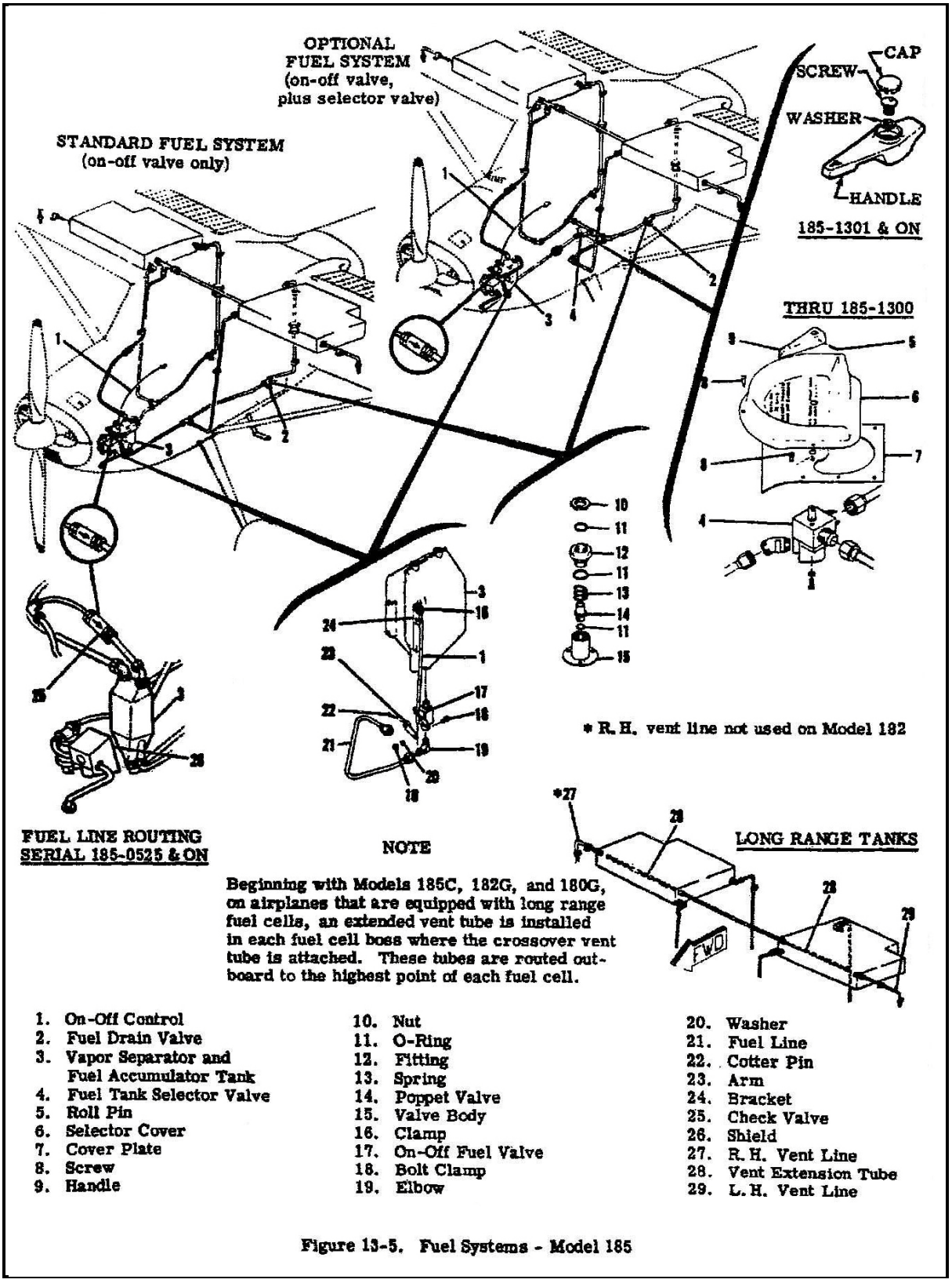
Other Finding

1. The aircraft was equipped with a 406 MHz emergency locator transmitter (ELT) and a SPOT™ satellite device. Both functioned as designed and led to the timely location of the crash site.

This report concludes the Transportation Safety Board's investigation into this occurrence. Consequently, the Board authorized the release of this report on 20 July 2010.

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

Appendix A – Fuel System Diagram



1. On-Off Control
2. Fuel Drain Valve
3. Vapor Separator and Fuel Accumulator Tank
4. Fuel Tank Selector Valve
5. Roll Pin
6. Selector Cover
7. Cover Plate
8. Screw
9. Handle
10. Nut
11. O-Ring
12. Fitting
13. Spring
14. Poppet Valve
15. Valve Body
16. Clamp
17. On-Off Fuel Valve
18. Bolt Clamp
19. Elbow
20. Washer
21. Fuel Line
22. Cotter Pin
23. Arm
24. Bracket
25. Check Valve
26. Shield
27. R. H. Vent Line
28. Vent Extension Tube
29. L. H. Vent Line

Figure 13-5. Fuel Systems - Model 185

Appendix B – Aircraft Flight Path