Transportation Safety Board of Canada

Bureau de la sécurité des transports du Canada

AVIATION INVESTIGATION REPORT
A13Q0098

FORCED LANDING FOLLOWING FUEL EXHAUSTION
AVIATION FLYCIE INC.
BEECHCRAFT KING AIR 100, C-GJSU
MONTRÉAL/ST-HUBERT AIRPORT, QUEBEC, 8 NM E
10 JUNE 2013

Canada

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Summary

The Beechcraft King Air 100 (registration C-GJSU, serial number B-88) operated by Aviation Flycie Inc. took off from the Montréal/St-Hubert Airport, Quebec, on a local flight under visual flight rules with 1 pilot and 3 passengers on board. As the aircraft approached Runway 24R at the Montréal/St-Hubert Airport, both engines (Pratt & Whitney Canada, PT6A-28) stopped due to fuel exhaustion. The pilot diverted to the St-Mathieu-de-Beloeil Airport, Quebec, and then attempted a forced landing in a field 0.5 nautical mile west of the St-Mathieu-de-Beloeil Airport. The aircraft struck the ground 30 feet short of the selected field, at 1725 Eastern Daylight Time. The aircraft was extensively damaged, and the 4 occupants sustained minor injuries. The emergency locator transmitter activated during the occurrence. The flight took place during daylight hours, and there was no fire.

Le présent rapport est également disponible en français.

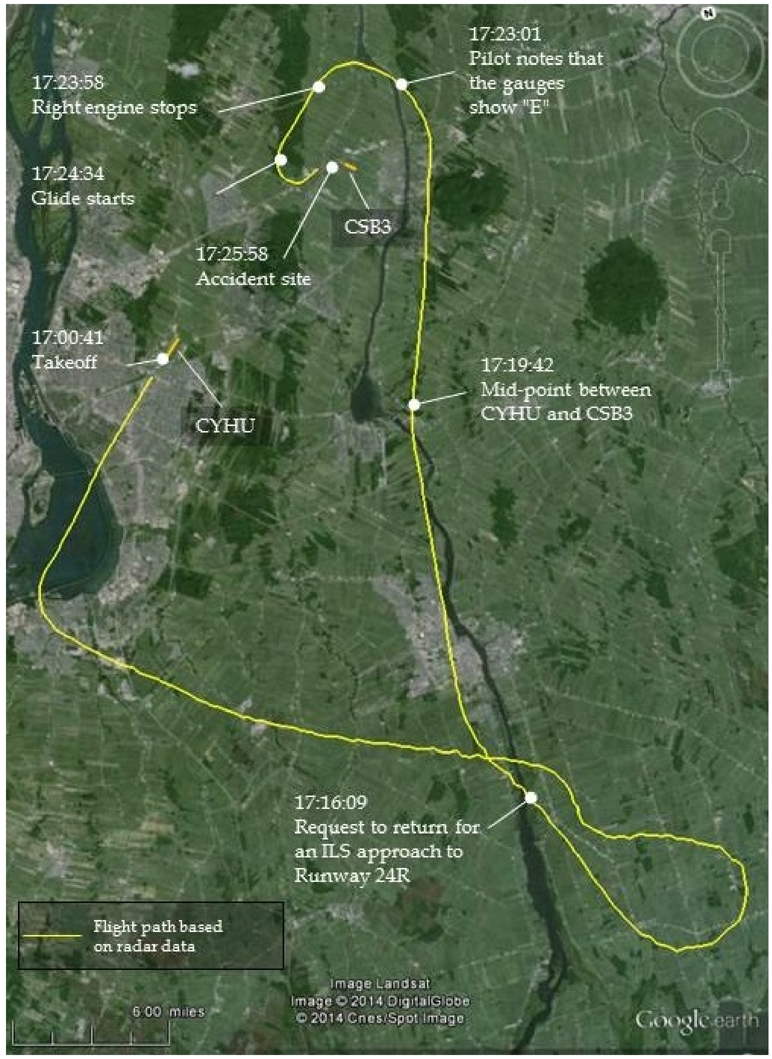
Table of contents

1.0 Factual information

1.1 History of the flight

The purpose of the flight was to check the rudder trim indicator and to confirm a potential synchronization problem between the autopilot and the global positioning system (GPS). The pilot completed the preflight walkaround inspection of the aircraft. The engines were started shortly before 1653.[1] The aircraft, which was at its base at the Montréal/St-Hubert Airport (CYHU), Quebec, took off at 1700 for a planned 15- to 20-minute visual flight rules (VFR) flight. The person responsible for maintenance (PRM) of the company, 2 passengers, and the pilot were on board.

Figure 1. Aircraft flight path based on radar data (Source: GoogleEarth, with TSB annotations)



At approximately 1714, once the tests were completed, the aircraft, which was about 25 nautical miles (nm) south of CYHU, set a direct course for CYHU. At 1716, the pilot advised air traffic control (ATC) that the tests had been completed and asked to return to CYHU with a simulated instrument landing system (ILS) approach to Runway 24R (Figure 1).

After receiving the ATC clearance, under radar control, the aircraft turned north. At 1719:42, the aircraft reached the midpoint between CYHU and the St-Mathieu-de-Beloeil Airport

1 All times are Eastern Daylight Time (Coordinated Universal Time minus 4 hours).

(CSB3), Quebec.[2] Subsequently, at an altitude of 3000 feet above sea level (asl), the aircraft followed an arc with a radius of approximately 3 nm from CSB3.

At 1722:52, the propeller sound fluctuated, as the fault warning light and RH FUEL PRESSURE light illuminated.[3] The pilot noted that the engine nacelle fuel tank gauges showed “E”.[4] The pilot activated the left and right auxiliary boost pumps and opened the crossfeed valve. At 1723:44, the aircraft intercepted the localizer of Runway 24R at CYHU at an altitude of 2800 feet asl. At 1723:58, the propeller sound fluctuated again, and the right engine stopped (Figure 2).

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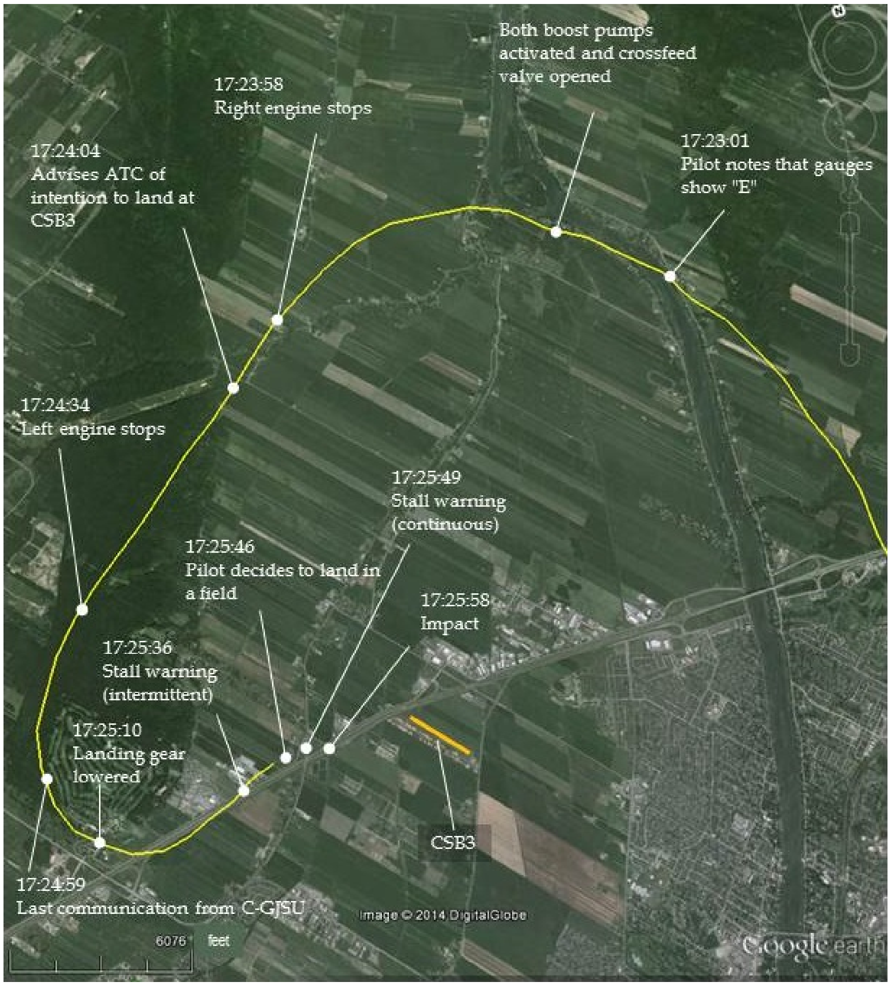
2 The aircraft was located 2 minutes 44 seconds from these airports.

3 Low fuel pressure in the right engine.

4 The needle points to “E” when the corresponding fuel tank is empty.

Figure 2. Aircraft flight path, based on radar data (Source: GoogleEarth, with TSB annotations)



At 1724:04, when the aircraft was 2.5 nm northwest of CSB3[5] and 2600 feet asl with a ground speed of 190 knots,[6] the pilot advised the controller they were going to land at CSB3 instead of CYHU.

At 1724:15, the controller cleared C-GJSU for a left turn toward CSB3.

At 1724:34, when C-GJSU was 2400 feet asl, 7.4 nm away from the runway and on a path toward CYHU, the left engine stopped. The pilot initiated a left turn toward the new destination. Over the next 40 seconds, C-GJSU's ground speed dropped from 180 knots to 110 knots.

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5 The elevation of the St-Mathieu-de-Beloeil Airport (CSB3), Quebec, is 47 feet above sea level (asl).

6 The aircraft's position, altitude (rounded to 100 feet) and ground speed (rounded to 10 knots) were recorded by radar at Montréal, Quebec.

At 1724:47, the controller provided traffic information to C-GJSU and cleared C-GJSU to the enroute frequency. The pilot acknowledged immediately. There was no further communication by C-GJSU.

At 1725:10, during the turn, when the aircraft was at the highest point of the turn at 1600 feet asl, the pilot lowered the landing gear. At 1725:36, when C-GJSU was 1000 feet asl, the stall warning horn sounded, then sounded 3 more times over the next 10 seconds (Figure 2).

At 1725:42, when the aircraft was approximately 450 feet above ground level (agl) and 0.85 nm from the threshold of Runway 15, the pilot decided to land in a field to the right. Beginning at 1725:49, the stall warning horn sounded continuously until the aircraft struck the ground.

Twelve seconds before impact, the pilot warned the PRM, who was seated in the co-pilot seat, that a forced landing was imminent. At that point, the PRM was not aware that the engines had stopped. The PRM immediately alerted the other 2 passengers that a forced landing was imminent and warned them to hold on tight.

Four seconds later, C-GJSU experienced an aerodynamic stall. The right wing touched the ground at an angle of approximately 45°, then the aircraft hit a fence and a tree before severing 2 electrical wires and violently striking the grass-covered ground. The aircraft kept moving for another 120 feet before coming to a stop on its belly, approximately 0.5 nm southwest of CSB3.

The 4 occupants, who sustained minor injuries, egressed by means of the emergency exit on the right side of the aircraft, which was extensively damaged.

1.1.1 Significant events in relation to the fuel on board

To determine the point at which C-GJSU could no longer reach its original destination airport, investigators calculated the quantity of fuel on board at key points or events in the flight and the flight times required to reach CYHU from each of those points at an average ground speed of 180 knots and with no allowance for a circuit prior to landing (Table 1).

Table 1. Fuel on board and flight times required to reach CYHU at key points in the flight

Key point in flight	Time	Fuel on board (minutes:seconds)	Flight time to CYHU (minutes:seconds)*
Takeoff from CYHU	1700:41	23:53	NA
Farthest position from CYHU	1713:37	10:57	09:00
Request to return for ILS 24R	1716:09	08:25	06:20
Midpoint between CYHU and CSB3	1719:42	04:52	02:44
Gauges show "E"	1723:01	01:33	04:12
Right engine stops	1723:58	00:36	03:09
ATC advised of diversion to CSB3	1724:04	00:30	03:03
Left engine stops, glide begins	1724:34	0	02:33
Impact	1725:58	NA	NA

* Calculated using a constant ground speed of 180 knots.

1.2 *Injuries to persons*

Table 2. Injuries to persons

	Crew	Passengers	Others	Total
Fatal	–	–	–	–
Serious	–	–	–	–
Minor/None	1	3	–	4
Total	1	3	–	4

1.3 *Damage to aircraft*

Both propellers were detached from their engines and showed damage consistent with an engine not producing power at the time of impact. Examination of the propellers showed that their blades were at a fine pitch angle. Both engines were partly torn off their engine mounts at the firewall (Photo 1).

Photo 1. View of the wreckage (Source: Régie intermunicipale de police Richelieu-Saint-Laurent)

1.4 *Other damage*

On short final approach toward the field, the aircraft severed 2 electrical wires.

1.5 Personnel information

1.5.1 General

Table 3. Pilot information

Licence	Airline transport pilot licence
Medical expiry date	01 January 2014
Total flying hours	4301
Hours in the last 90 days	87.6
Hours on type in the last 90 days	87.6
Hours off duty prior to the work period	18

The pilot-in-command was the company chief pilot and was conducting the flight as a single pilot. The pilot held a valid airline transport pilot licence and was qualified for the flight in accordance with existing regulations. According to the curriculum vitæ submitted to Aviation Flycie Inc., the pilot had logged a total of 4200 flying hours, which included 1100 hours on twin-engine aircraft as pilot-in-command and 400 hours on the Beechcraft King Air as co-pilot.

A partial copy of the pilot's logbook[7] showed that the pilot had logged 216 flying hours as co-pilot on the Beechcraft King Air with the previous employer, despite lacking the necessary qualifications.[8] Further, the investigation revealed that the training had not been completed and that those hours were in the capacity of observer.

Due to lack of documentation,[9] the investigation was unable to determine exactly what flying experience the pilot had on the Beechcraft King Air. At the time of the accident, the pilot had logged approximately 88 flying hours on the Beechcraft King Air 100 (BE10)[10] while employed at Aviation Flycie Inc., including 65 hours in commercial operations.

1.5.2 Pilot history

The pilot obtained a commercial pilot licence in March 1996, a Class 4 Instructor rating in July 1997, and a Class 1 Instructor rating in March 2001. In April 2001, the pilot obtained a multi-engine rating on the second attempt; the first flight test result had been failure because the pilot had not feathered the propeller of the affected engine during the engine failure exercise. The pilot had obtained an instrument rating in October 2001, and an airline

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7 On file with Transport Canada.

8 The pilot had not completed the training, and had not completed a pilot proficiency check (PPC) nor a pilot competency check (PCC).

9 The pilot was not able to provide the logbook to the TSB.

10 International Civil Aviation Organization, Document 8643 – Aircraft Type Designators.

transport pilot licence in August 2005. In 2006, the pilot was hired as a training pilot and was appointed chief pilot of a fleet of Cessna 310s used for fire patrols. In 2007, the pilot failed a Transport Canada (TC) assessment to become an approved check pilot (ACP).

In 2007, the pilot was hired by an air carrier as a first officer,[11] but experienced significant difficulties in the simulator and required several additional training sessions. In January 2008, the pilot was dismissed after failing initial training. In 2009, the pilot was hired by a flight school as a flight instructor and, in 2010, another air carrier hired the pilot to carry out a fire patrol contract. In June 2011, the pilot was hired as a co-pilot on the Beechcraft King Air, but after 2 flights and a poor performance, the pilot's initial training on the aircraft was suspended. At that point, the employer permitted the pilot to fly as an observer pilot to gain experience. However, in October 2011, the company dismissed the pilot due to performance that was generally poor and did not meet expectations.

According to a curriculum vitæ, the pilot had occasionally ferried various aircraft in Canada and in the United States, including the Beechcraft King Air. However, in the absence of a logbook, the investigation could not confirm those flights.

In November 2012, the pilot was hired by Aviation Flycie Inc. to hold the position of chief pilot once the company received its air operator certificate. In order for the company to meet the requirements for the certificate, the pilot wrote the company operations manual (COM), its standard operating procedures (SOP), and its flight crew training program. The pilot passed the written chief pilot exam in December 2012 and, after an initial failure, passed the chief pilot interview in February 2013.

Between 13 and 18 March 2013, the pilot received flight training on the BE10, consisting of 11.1 flying hours. Despite experiencing difficulties with the in-flight exercises involving handling and control of the aircraft, steep turns, engine failure, crew coordination, leveling off and maintaining altitudes, and using checklists, the pilot was recommended for an aircraft pilot proficiency check (PPC).

On 18 March 2013, the pilot passed the PPC on the company's BE10 (see section 1.18.1.2 in this report). However, 4 exercises had received a score of "2".[12] After the PPC, the TC ACP reported concerns about the general weakness of the chief pilot candidate to the technical

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11 Operation of an air operator under Subpart 705 of the *Canadian Aviation Regulations* (CARs).

12 The score of "2" is the basic standard. Major deviations from the qualification standards occur, which may include momentary excursions beyond prescribed limits, but these are recognized and corrected in a timely manner. When an approved check pilot (ACP) assesses at least one sequence or item as "(1)", the flight check will receive a General Assessment of "Failed". A pilot proficiency check (PPC) that has five or more sequences or items assessed as "(2)" will also receive a General Assessment of "Failed". (Source: Transport Canada, TP 14727, *Pilot Proficiency Check and Aircraft Type Rating Flight Test Guide*, 2007)

team lead and to the TC senior operations inspector responsible for Aviation Flycie Inc. (see section 1.18.1.3).

The investigation revealed that the chief pilot candidate's performance for former employers had been below the standards set by those employers in the vast majority of cases, for reasons that included:

- non-compliance with company policies,
- laxity in carrying out established procedures, and
- general weakness in carrying out tasks required while in flight.

Neither TC nor Aviation Flycie Inc. had contacted any of the former employers; nor were they required to do so. Further, TC retains test results but does not track test failures to monitor pilot performance.

1.5.3 Pilot's work schedule

It could not be determined based on a review of the pilot's work schedule whether, at the time of the accident, the pilot met the requirements specified in the COM related to maximum flight duty time and rest periods.

According to the COM, pilots must enter their flight duty time and their flying time in an electronic spreadsheet after each flight. The operations manager must ensure that pilots' schedules comply with regulations governing flying times and flight duty times in accordance with *Canadian Aviation Regulations* (CARs) 700.15. TC had issued operations specifications to the company to increase its limits for flying times[13] and flight duty times.[14]

A calculation of the pilot's flying time showed that it did not exceed the limits prescribed in CARs 720.15. However, no flight duty time had been entered in the log when the pilot was performing the duties of chief pilot; the log showed that the chief pilot was off duty when not flying. Therefore, based on the log alone, the pilot's flight duty times or rest times could not be calculated.

The electronic spreadsheet used by the company was different from the duty time log published in the COM. However, all of the fields of the published log were found in the electronic spreadsheet.

Based on the available information, there is no indication that fatigue was a factor in the accident.

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13 Operations specification No. 92.

14 Operations specification No. 93.

1.5.4 Crew resource management and pilot decision-making training

The pilot had not received any TC-approved training in pilot decision making or in crew resource management at Aviation Flycie Inc., and such courses are not required by regulations.

1.6 Aircraft information

1.6.1 General

The Beechcraft King Air 100 is a small, pressurized turboprop twin-engine aircraft, often used for charter flights and business aviation. The aircraft was configured to fly with 2 crew members and to carry a maximum of 9 passengers.

Table 4. Aircraft information

Manufacturer	Beech Aircraft Corporation
Type and model	King Air 100
Year of manufacture	1971
Serial number	B-88
Certificate of airworthiness	Commercial
Number of airframe hours/cycles	13 616.9/10 999
Engines	2 (Pratt & Whitney Canada, PT6A-28)
Maximum authorized take-off weight	11 846 pounds
Recommended fuel types	Jet A, Jet A-1, Jet B
Type of fuel used	Jet A-1

1.6.2 Airworthiness

The maintenance records showed that C-GJSU was maintained in accordance with the approved procedures set out in the company's maintenance control manual. Aviation Flycie Inc. had hired an independent, TC-approved maintenance organization to perform inspections and carry out the maintenance of the aircraft. The latest inspection of the aircraft had taken place on 03 June 2013 as part of the 100-hour inspection program. At that time, the aircraft had a total of 13 610 airframe hours. The company's maintenance record for the aircraft showed no deferred maintenance items.

1.6.3 Raisbeck modification

The aircraft was modified with a Raisbeck Engineering kit that included dual aft body underside strakes and 4-blade propellers. These modifications were carried out under a supplemental type certificate approved by TC and by the U.S. Federal Aviation Administration (FAA). The operation of the aircraft is described in the original flight manual for the Beechcraft aircraft and in the supplemental aircraft flight manual (AFM) by Raisbeck Engineering (part number 91-100/A100).

The Hartzell/Raisbeck constant-speed, 4-blade propellers provide 2000 revolutions per minute (rpm) at takeoff, while 1750 rpm are recommended for cruising flight. Once the propeller rpm is set, it is maintained automatically. When the propeller rpm drops, the governor reduces the pitch of the propeller to maintain the rpm, and vice versa.

When an engine fails, the propeller rpm drops momentarily and the propeller's governor reduces the pitch to maintain the selected rpm. The relative wind pushing on the propellers provides the energy required to keep them spinning at the same rpm. According to Hartzell, the rpm is maintained as long as the aircraft remains at a calibrated air speed above the range of 110 to 116 knots.

1.6.4 Fuel system

The fuel system is designed to feed the 2 engines independently of each other. Each engine is supplied by 4 wing tanks with a total capacity of 130 U.S. gallons of usable fuel. This fuel flows into an engine nacelle tank with a usable capacity of 57 U.S. gallons, for a total of 374 U.S. gallons (i.e., 2618 pounds for Jet A-1 fuel at 15°C).[15]

A warning light illuminates on the annunciator panel of the instrument glareshield when the float switch of a nacelle tank detects a drop in fuel level.

Primary and secondary boost pumps installed in the nacelle tanks each provide enough fuel pressure to run the engines. The secondary boost pumps are not in operation under normal conditions. When fuel pressure drops below 9 to 11 psig,[16] the red FUEL PRESSURE warning light on the affected side (right or left) illuminates. If a boost pump fails, activation of the secondary pump will increase the fuel pressure, and the associated light will turn off.

Mainly used when an engine fails, the crossfeed valve is opened to supply the still-operating engine with fuel from the tanks on the opposite side. A lever-lock switch located between the nacelle tank fuel gauges activates the crossfeed valve, and a white FUEL CROSSFEED light illuminates on the annunciator panel. The crossfeed line does not transfer fuel from one tank to another; however, it can be used to supply either one or both engines from the tanks on one side.

From time to time, the needles of the nacelle tank fuel gauges had been observed to be jerky in their movement; at these times, the needles would briefly stop at a given value. However, no anomaly related to fuel gauges was recorded in the logbook or in the aircraft maintenance record, nor was one reported to the PRM.

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15 Transport Canada, TP14371, *Transport Canada Aeronautical Information Manual* (TC AIM), section 3.5.8 of the CARs chapter.

16 Pressure in pounds per square inch.

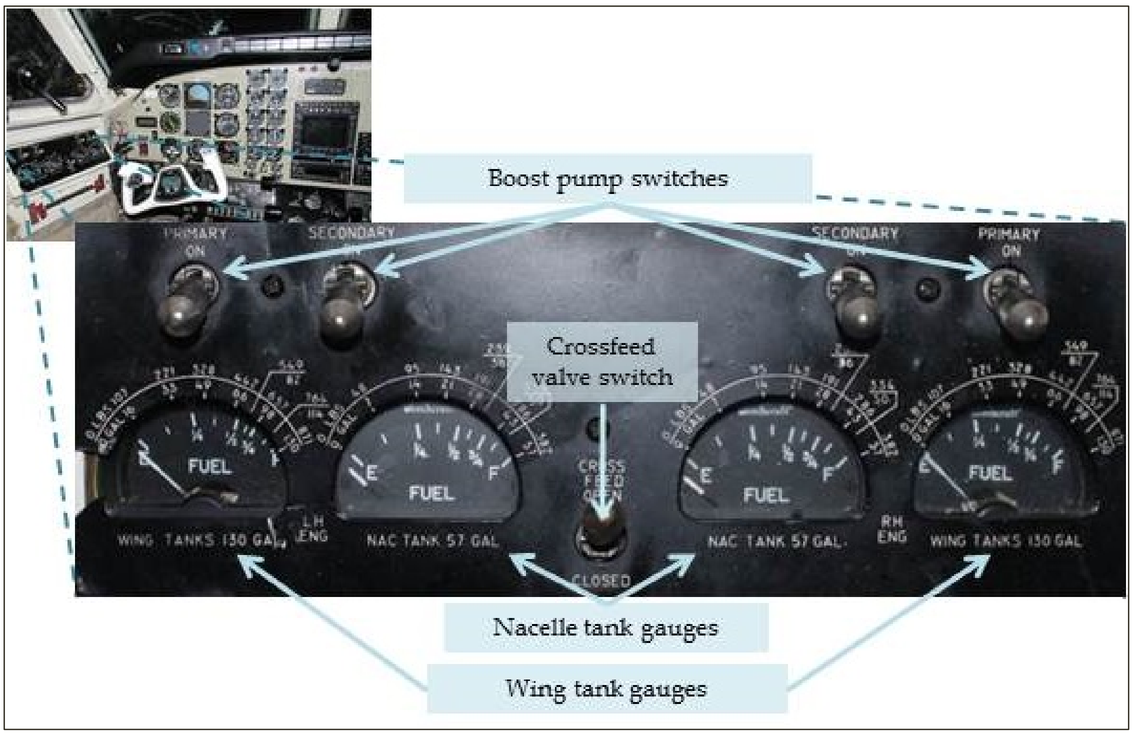
1.6.4.1 Maintenance work

On 22 May 2013, the left primary fuel pump had been replaced[17] in accordance with approved procedures. The fuel gauges were not recalibrated after the pump was replaced, nor was recalibration required.

1.6.4.2 Fuel panel

The fuel panel is located on the pilot's left (Figure 3). It includes the 4 fuel gauges, the switches of the 2 primary boost pumps and those of the 2 secondary boost pumps, and the crossfeed valve switch. One wing tank gauge and one nacelle tank gauge are located on each side of the crossfeed valve switch.

Figure 3. Fuel panel and switches



The fuel gauges are graduated from "E" (empty) to "F" (full). Fuel quantity is displayed in fractions, pounds, and gallons. The gauges are not graduated in linear fashion; the needle moves in smaller increments as it approaches the "F" mark. For example, the "¼ full" mark is located near the middle of the dial. The scale of the wing tank gauges is graduated from 0 to 130 U.S. gallons, whereas the scale of the nacelle tank gauges is graduated from 0 to 57 U.S. gallons (Figure 4).

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17 The previous day, the pilot had recorded in the aircraft logbook that the pump was out of service.

Figure 4. Graduation of the gauges

Calibration of the fuel gauges is not required, and no adjustment is called for in the aircraft maintenance manual. In the event that a gauge provides a faulty reading, the instrument is replaced.

1.6.5 *Hourly fuel consumption*

The aircraft is equipped with 2 fuel flow indicators that display fuel flow in pounds per hour for each engine. Fuel consumption varies according to the power setting, altitude, and temperature. Generally speaking, each engine of the BE10 consumes an average of 300 pounds of fuel per hour. However, for flight planning purposes, specific calculations of hourly consumption are used for taxiing, takeoff, climb, descent, and approach. Aviation Flycie Inc. used an online tool provided by FltPlan.com to calculate fuel requirements.

1.6.6 *Quantity of fuel on board the aircraft*

Examination of the aircraft showed that all of the fuel tanks were empty at the time of impact. During the preflight walkaround inspection, the pilot did not remove the filler caps of the fuel tanks to visually verify the quantity of fuel, and was not required to do so.

Before departure, the pilot estimated that the left nacelle tank contained between 280 and 300 pounds of fuel, and that there were between 300 and 320 pounds of fuel in the right nacelle tank. However, the wing tanks were empty and the 2 amber NACELLE NOT FULL lights were illuminated before the flight commenced.

Basing calculations on the CARs requirements for private VFR flights, the pilot determined that 500 pounds of fuel were needed to carry out the 20-minute flight and to land with a reserve of 30 minutes, or 300 pounds, of fuel. The pilot therefore decided to refuel at the end of the maintenance flight,[18] to avoid having to refuel twice (i.e., both before and after the flight).

The weight-and-balance form completed for the flight showed that there were 580 pounds of fuel at the time of departure from CYHU; that of the previous flight showed 1100 pounds at the time of departure from Montréal/Pierre-Elliott-Trudeau International Airport (CYUL), Quebec; and that of the flight before that showed 1860 pounds at the time of departure from Charlottetown Airport (CYYG), Prince Edward Island.

1.6.6.1 *Assessment of the quantity of fuel at departure from Montréal/St-Hubert Airport*

1.6.6.1.1 *General*

To accurately determine the quantity of fuel on board at the time of departure from CYHU and to verify the possibility of a fuel leak during the flight, 2 reverse calculations of fuel consumption were carried out:

1. from CYHU to the time of fuel exhaustion (the occurrence flight);
2. from the last fuelling until the time of arrival at CYHU (4 previous flights).

1.6.6.1.2 *Fuel consumed during the occurrence flight*

Since the test flight was carried out at a relatively low speed, an hourly flow of 550 pounds, representative of a lower power setting, was used to calculate the quantity of fuel consumed during the occurrence flight. Given that 23 minutes and 53 seconds elapsed before the second engine stopped, it was estimated that the aircraft had taken off with approximately 220 pounds of fuel on board. Using an estimation that the aircraft consumed 40 pounds while taxiing, the quantity of fuel on board when its engines were started at CYHU was determined to have been approximately 260 pounds.

1.6.6.1.3 *Cross-checking of fuel on board at CYHU*

To cross-check the quantity of fuel on board at the time of departure from CYHU, fuel consumption was tracked from the last fuelling to the time of arrival at CYHU. The aircraft logbook, flight documents, and fuelling slips were used for this purpose.

The last fuelling took place at Rivière-du-Loup Airport (CYRI), Quebec, on 07 June 2013. After that, the aircraft made a stop at Fredericton Airport (CYFC), New Brunswick, and another at Charlottetown Airport (CYYG), Prince Edward Island. On 09 June 2013, the pilot had 527 pounds of fuel added before taking off for CYHU with a stop at Montréal/Pierre-Elliott-Trudeau International Airport (CYUL), Quebec.

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[18] There is no operational impact or administrative fees associated with fuelling.

The quantity of fuel on board at the time of takeoff from CYHU was first calculated based on the consumption estimates used for flight planning since the last fuelling (Table 5).

Table 5. Calculation of fuel on board the aircraft based on estimated flying times

Date	Point of departure	Destination	Fuel (pounds)			
			Departure	Consumed*	Arrival	Added
07 June 2013	Rivière-du-Loup	Fredericton	2525**	612	1913	–
07 June 2013	Fredericton	Charlottetown	1913	590	1323	527
09 June 2013	Charlottetown	Montréal	1850	1427	423	–
09 June 2013	Montréal	St-Hubert	423	252	171	–

* Comprises fuel consumption during the flight and fuel consumed by taxiing (20 pounds at arrival and 40 pounds at departure).

** According to weight-and-balance specifications, the pilot would use 2524.5 pounds of fuel when all of the tanks on the aircraft were full.

Next, the actual flying times recorded in the logbook were used, with a representative hourly flow for this type of aircraft[19] since the last fuelling (Table 6).

Table 6. Calculation of fuel on board the aircraft based on actual flying times

Date	Point of departure	Destination	Fuel (pounds)			
			Departure	Consumed*	Arrival	Added
07 June 2013	Rivière-du-Loup	Fredericton	2525	660	1865	–
07 June 2013	Fredericton	Charlottetown	1865	540	1325	527
09 June 2013	Charlottetown	Montréal	1852	1460	392	–
09 June 2013	Montréal	St-Hubert	392	180	212	–

* Comprises fuel consumption during the flight and fuel consumed by taxiing (20 pounds at arrival and 40 pounds at departure).

According to the planning data for these 4 flights (Table 5), approximately 170 pounds of fuel remained on board the aircraft at CYHU. But based on the actual flying times of these flights (Table 6), approximately 210 pounds of fuel remained at that point.

Based on the calculation of fuel consumption during the occurrence flight (section 1.6.6.1.1), the quantity of fuel on board at the time of departure from CYHU was estimated at approximately 260 pounds. The conclusion that C-GJSU had at most 260 pounds of fuel is consistent with what was indicated on the fuel gauges, as shown in Figure 5. Therefore, C-

19 Fuel consumption of 600 pounds for the first hour, 500 pounds for each additional hour, 20 pounds for taxiing at arrival, and 40 pounds for taxiing at departure.

GJSU had approximately 260 pounds of fuel on board when it took off from CYHU, and did not experience a fuel leak during the occurrence flight.

Figure 5. Illustration of the quantity of fuel before the occurrence flight

1.6.7 *Automatic feathering system*

The aircraft was equipped with an automatic feathering system in case of engine failure. The system is designed for use exclusively during takeoff and landing. It is armed before takeoff, then the arming switch is moved to the OFF position during the climb. When the landing checklist is carried out, the system is armed again a few moments before the landing gear is lowered. In this occurrence, the automatic feathering system was not armed.

1.6.8 *Normal procedures and procedures in abnormal and emergency situations*

The aircraft operating procedures are published in the AFM. As the BE10 is certified for single-pilot, instrument flight rules (IFR) flights, the manufacturer developed these procedures for a single pilot.

Pursuant to CARs 703.107, Aviation Flycie Inc. had developed SOPs for operation of its aircraft with 2 pilots,[20] while allowing crew members to use the aircraft within the limitations specified in the AFM. The SOPs set out the company rules and procedures, procedures governing the operation of its aircraft, and procedures for use of checklists. TC reviewed Aviation Flycie Inc.'s SOPs and determined that they were in compliance with CARs 703.107. However, the content of SOPs related to operations under CARs Subpart 703 was reviewed only briefly and was not subject to TC approval. The same applied to checklist SOPs.

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20 At the time of the accident, Aviation Flycie Inc. could not operate its aircraft with a single pilot.

1.6.8.1 Checklists in abnormal and emergency situations

Normally, checklists comprise aspects of the SOPs that are deemed important for flight safety. Although Aviation Flycie Inc. had developed checklists for the BE10, including a checklist for use in normal situations (CHKL), it had not developed its own checklist for use in abnormal and emergency situations (ECHKL). The company's crews used the ECHKL developed by the previous owner/operator of C-GJSU. The investigation found that some emergency procedures published in the Aviation Flycie Inc. SOPs contained references to that ECHKL, which itself did not contain such procedures.

1.6.8.2 Normal procedures

The purpose of SOPs for normal situations is to guide flight crews through verifying that the aircraft systems are functioning properly and ensuring that the configuration of the aircraft is appropriate for the planned or current phase of flight.

While a few minor discrepancies were noted between the AFM and the pre-takeoff CHKL, these discrepancies were not a contributing factor in the accident.

According to the company CHKL, the crew must verify the quantity of fuel twice before starting the engines: once when carrying out the COCKPIT PRE-FLIGHT CHECK,[21] and once more as part of the PRE-START[22] check. These checks are carried out from memory. It is reasonable to assume that, while checking the boost pumps and the crossfeed valve (during the BOOST PUMP & XFEED CHK),[23] the pilot-in-command also observes the fuel gauges, since they are in close proximity to the pump switches. However, the pilot did not carry out the BOOST PUMP & XFEED CHK before the occurrence flight.

Once in flight, only the CRUISE CHK[24] requires the crew to verify the quantity of fuel. It was at 1708, after reaching the cruising altitude of 5500 feet, that the pilot was required to perform the cruise check. At that point, the aircraft was approximately 16 nm south of CYHU.

1.6.8.3 Emergency procedures

The emergency procedures are published in the AFM and are repeated in the SOPs and in the ECHKL. There are slight discrepancies among all of them, none of which are crucial to flight safety. The emergency procedures published in Aviation Flycie Inc.'s SOPs call for some items requiring immediate action to be carried out from memory. Those items are preceded by an asterisk (*).

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21 Item 15. Fuel Qty (main + nac).

22 Item 11. Fuel quantity.

23 Item 14 of the *COCKPIT PRE-FLIGHT CHECK.*

24 Item 9. Fuel.

In this occurrence, the anomalies that were observed in the cockpit occurred in the following chronological order:

1. The rpm of the right engine propeller changed.
2. The RH FUEL PRESSURE light illuminated.
3. The fuel gauges indicated "E" (empty).
4. The rpm of the right engine propeller changed.
5. The right engine stopped.
6. The rpm of the left engine propeller changed.
7. The left engine stopped.
8. The stall warning horn sounded.
9. An aerodynamic stall occurred on short final approach at low altitude.

1.6.8.3.1 RH FUEL PRESSURE light

A description of each warning light, followed by the probable reason for its illumination, is found in the pilot operating handbook. If the RH FUEL PRESSURE light illuminates, the handbook presumes that the boost pump has failed:

	ANNUNCIATOR PANEL	
NOMENCLATURE	COLOR	PROBABLE CAUSE FOR ILLUMINATION
[…]		
RH FUEL PRESSURE	Red	Fuel pressure failure on right side. (Check boost pumps)[25]

The pilot must then carry out the following procedure:

BOOST PUMP FAILURE

1. Both Boost Pumps – ON (primary and secondary)
2. Failed Boost Pumps – OFF[26]

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[25] Raytheon Aircraft, *Beech King Air 100 Pilot's Operating Manual* (15 January 1970), Supplemental Operational Data, Systems Descriptions, p. 10-12.

[26] Raisbeck Engineering, *King Air 100 FAA Flight Manual* (16 February 1973), Section III, Emergency Procedures, p. 3-4.

1.6.8.3.2 Procedure in case of in-flight engine failure

Following an engine failure, the GENERATOR and INVERTOR OUT red warning lights will illuminate, and the engine gauges for the gas generator (GAS GEN) and torque parameters will indicate zero.

The in-flight engine failure procedure published in the BE10 AFM is intended to ensure that all critical tasks are carried out sequentially, in order of priority.

The engine failure procedure contained in Aviation Flycie Inc.'s SOPs repeats all of the items of the AFM procedure; however, the company requires[27] its pilots to carry out the first 6 items of the procedure from memory:

> *ENGINE FAILURE OR FIRE* (Flight)
>
> Affected Engine:
>
> 1. Power Lever – IDLE
> 2. Propeller – FEATHER
> 3. Condition Lever – CUT-OFF
> 4. Fuel Firewall Valve – CLOSED
> 5. Bleed Air Valve – AS REQUIRED
> 6. Fire Extinguisher – ACTUATE (as required)
> 7. Clean-up (inoperative engine):
>   a. Auto-ignition – OFF
>   b. Fuel Boost Pump – OFF
>   c. Generator – OFF
>   d. Fuel Control Heat – OFF
>   e. Propeller Synchronizer - OFF
> 8. Electrical Load - MONITOR[28]

Carrying out the first item of the procedure enables the pilot to, among other things, identify and confirm which engine has stopped, before shutting it down. Performing the second item eliminates the drag caused by the propeller windmilling.

During this occurrence, none of the checklist items were carried out.

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27 Aviation Flycie Inc., *BE10 Procédures anormales et d'urgence*, Volume 0.1, 3.2.11 Engine failure/Emergency shutdown, p. 8.

28 Raisbeck Engineering, *King Air 100 FAA Flight Manual* (16 February 1973), Section III, Emergency Procedures, p. 3-2.

1.6.8.3.3 Procedure in case of failure of the second engine

If the second engine stops, the pilot must perform the following procedure:

> *ENGINE FLAME-OUT* (2nd engine)
>
> 1. Power Lever – IDLE
> 2. Propeller – DO NOT FEATHER
> 3. Condition Lever – CUT-OFF
> 4. Conduct Air Start Procedures
>
> NOTE
>
> The propeller will not unfeather without engine operating.[29]

The procedure published in the company SOPs is similar to that of the AFM, except that all of the items must be carried out from memory. Since the possibility of fuel exhaustion is deemed to be very unlikely, no emergency procedure takes that possibility into consideration. The AFM, SOPs and the ECHKL do not mention warning signs of fuel exhaustion. Thus, the procedure in the AFM, the SOPs and the ECHKL for dealing with a failure of the second engine attributes the engine failure to a loss of combustion, and directs the pilot to the procedure for restarting an engine in flight.

No particular steps are indicated in the SOPs or in the AFM in the event that the engine does not restart.

1.6.8.3.4 Forced landing

There is no procedure for a forced landing in the AFM. However, Aviation Flycie Inc. had developed a procedure for that event. It was published in the SOPs (as follows), but was not included in the ECHKL.

> **3.2.16 Forced landing**
>
> 1. * Radio .... MAYDAY
> 2. * Transponder 7700
> 3. * Locator Beacon (If installed) .... EMER
> 4. * Seat Belt/ No Smoking Light .... ON
> 5. * Gear .... DOWN
> 6. * Flaps .... DOWN
> 7. * Airspeed .... 95 KTS

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29 Raisbeck Engineering, *King Air 100 FAA Flight Manual* (16 February 1973), Section III, Emergency Procedures, p. 3-2.

8. * Rate of Descent .... AS REQUIRED
9. * Condition Lever (prior to touchdown) ....CUT-OFF[30]

This procedure assumed that the engines were running. All of the items on the list had to be carried out from memory. During the forced landing attempt by the pilot in this occurrence, the flaps were not used.

No procedure or information was published to indicate what to do when gliding.

1.6.8.4 Performance

According to the weight-and-balance form for the flight, the weight of C-GJSU with zero fuel was 7794 pounds. At that weight, C-GJSU had an aerodynamic stall speed of 74 knots with flaps retracted; at 45° of bank, that stall speed would have increased to 88 knots.

The landing distance for C-GJSU, at an approach speed of 82 knots and from a height of 50 feet, was approximately 1900 feet, including the ground-roll distance of approximately 1000 feet.

1.7 Meteorological information

The weather conditions were favourable for a VFR flight. According to the weather report that was issued by the automated weather observation system (AWOS) at CYHU and that was in effect at the time of the accident, the conditions were as follows:

- wind from 130° magnetic (M) at 12 knots
- visibility of over 9 statute miles
- no cloud below 10 000 feet agl
- temperature 25°C, dew point 7°C, altimeter setting of 30.02 inches of mercury.

1.8 Aids to navigation

Not applicable.

1.9 Communications

A review of the communications between C-GJSU and NAV CANADA air traffic services showed that the pilot had not reported any problem with the aircraft's equipment or systems, and that there had been no problems related to communication with ATC.

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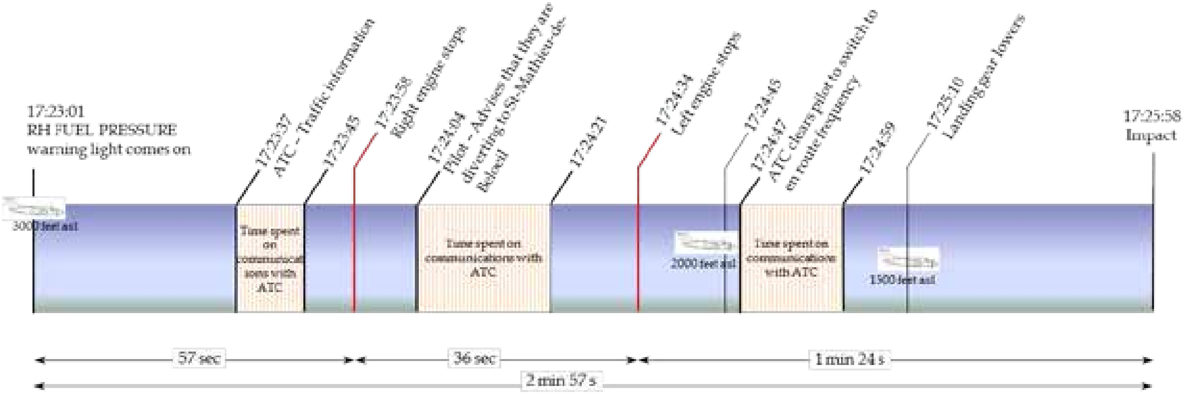
30 Aviation Flycie Inc., *BE10 Procédures anormales et d'urgence*, Volume 0.1, 3.2.16 Forced landing, p. 11.

There were 3 radio communications between C-GJSU and the Montréal terminal control area after the RH FUEL PRESSURE light illuminated (Figure 6).

Figure 6. Communications between the pilot and air traffic control (ATC)



After the right engine stopped, the pilot advised the controller that the flight would be diverting to CSB3, but did not provide a reason. Unaware of the flight's emergency status, the controller acted as per the *Air Traffic Control Manual of Operations* (ATC MANOPS) instructions for normal communications. As such, the information transmitted and the requests made by the controller constituted a source of distraction for the pilot. The last communication from the controller to C-GJSU took place 13 seconds after the second engine had stopped, and consisted of informing the pilot of nearby traffic and clearing the pilot to switch to the enroute frequency. The pilot acknowledged but did not report that an emergency situation was in progress.

The aircraft impacted the ground 1 minute later, in a field located 0.5 nm south of the selected runway. A "mayday" call had not been transmitted. In addition, the pilot's intention of landing at CSB3 from the opposite side of the approach circuit in use had not been communicated on the aerodrome's traffic frequency.

1.9.1 Communications in emergency situations

When a pilot is unable to continue the flight in accordance with a clearance received from ATC, that pilot must, to the extent possible, attempt to obtain a revised clearance before taking any other action, by using a distress or urgency signal if applicable. However, a pilot who is faced with an emergency is expected to take all steps deemed necessary to ensure the safety of the flight.

In an emergency situation, the crew must carry out the following priority tasks, in chronological order:

1. Keep control of the aircraft while assessing the situation.

2. Perform critical actions associated with the emergency.
3. Direct the aircraft toward the chosen place.
4. Inform others of their intentions and needs.

According to the *Transport Canada Aeronautical Information Manual* (TC AIM),

> An emergency situation is classified in one of the two following categories in accordance with the degree of danger or hazard present:
>
> a) *Distress*—A condition of being threatened by serious and/or imminent danger and of requiring immediate assistance. The spoken word for distress is MAYDAY, and it is pronounced three times.
>
> b) *Urgency*—A condition concerning the safety of an aircraft or other vehicle, or of some person on board or within sight, but which does not require immediate assistance. The spoken word for urgency is PAN PAN, and it is pronounced three times.[31]

ATC will assist pilots by all possible means when an emergency situation is declared. Flight priority is granted to an aircraft that has declared, or that is believed to be in, an emergency situation.

According to the TC AIM, a "distress call [MAYDAY] has absolute priority over all other transmissions. All stations hearing it shall immediately cease any transmission that may interfere with it and shall listen on the frequency used for the distress call."[32]

1.10 Aerodrome information

CSB3 is an uncontrolled airport located 8.5 nm east-northeast of CYHU, with a designated aerodrome traffic frequency of 122.7 MHz. It has a single runway (Runway 15/33), which is 2581 feet long and 50 feet wide, with a left-hand circuit. At the time of the occurrence, Runway 15 was the runway in use.

1.11 Flight recorders

C-GJSU was equipped with a digital cockpit voice recorder (CVR). Its recording of the occurrence flight was 31 minutes 19 seconds in length, and ended 9 seconds after impact.

The CVR data indicated that there were 4 instances of fluctuation in propeller sound,[33] which allowed investigators to determine the time of the first sign of a fuel supply problem, as well as the exact time at which each engine stopped. Subsequently, the loss of propeller

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31 Transport Canada, TP 14371, *Transport Canada Aeronautical Information Manual* (TC AIM), 5.11.1.

32 *Ibid.*

33 At 1722:52, 1723:58, 1724:10, and 1724:34.

synchronization made it possible to establish that at 1725:24, C-GJSU's speed had dropped below the range[34] required to maintain propeller rpm when windmilling.

The CVR recording also made it possible to determine the exact time at which the stall warning horn had sounded.

The aircraft was equipped with a single, intermittent-sound alarm whose purpose is to prevent belly landings with the gear up. This alarm should sound when one or both power levers are retarded below a power setting sufficient to maintain flight while the landing gear is retracted.

Based on a spectral analysis of the CVR recording, it was concluded that no power lever had been pulled back to the idle position, because no intermittent alarm indicating that the landing gear was up had sounded at any point after the engines had stopped.

1.12 Wreckage and impact information

C-GJSU experienced an aerodynamic stall while the pilot was attempting to make a forced landing in a field located 7.6 nm east-northeast of CYHU, 2700 feet west of the threshold of Runway 15 at CSB3.

On short final approach, the aircraft crossed over Highway 20 at very low altitude. Approximately 170 feet farther on, 40 feet short of the selected field, its right wing struck the ground. The aircraft subsequently hit a tree, then passed between 2 hydro poles, severing the bottom 2 wires. Markings left by one of the wires on the windshield showed that the aircraft had banked to the right at an angle of nearly 45°.

The aircraft slid on its belly on a trajectory of approximately 150°M and came to a stop perpendicular to the approach path, 120 feet from the first point of impact (Photo 2).

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34 Range between 110 and 116 knots.

Photo 2. Post-impact trajectory of C-GJSU (Source: Régie intermunicipale de police Richelieu-Saint-Laurent)

An examination of the wreckage showed that

- there were no flight control system anomalies;
- the flaps were retracted;
- the landing gear was down;
- there had been no fire during the flight, nor post-impact;
- no fuel leak had occurred;
- the fuel caps were firmly closed;
- the fuel tanks were empty; and
- the propellers were not feathered.

1.13 *Medical and pathological information*

The investigation determined that there was nothing to indicate that the pilot's performance was degraded by physiological factors.

1.14 *Fire*

There was no indication of fire before or after the occurrence.

1.15 *Survival aspects*

The cabin of the BE10 has a single door located at the rear of the aircraft, on the left side. A window over the right wing serves as the emergency exit. The cabin was configured with 5 passenger seats, which were positioned in rows and separated by a central aisle.

Both the pilot and the passenger who was in the right front seat were wearing 4-point harnesses. The pilot sustained minor injuries from an impact to the head due to lateral forces. After the aircraft had come to a stop, the passenger in the right front seat, who sustained a minor facial injury, entered the cabin and opened the emergency exit on the right side. All of the occupants evacuated the aircraft through that exit.

The 2 passengers seated in the cabin sustained minor injuries. They were seated in the second row and were facing forward. On impact, the right seat sustained a lateral deformation, collapsed slightly to the left, and partly obstructed the aisle.

1.15.1 Emergency locator transmitter

C-GJSU was equipped with an ARTEX ME 406-MHz emergency locator transmitter (ELT) (serial number 188-06275), capable of transmitting on the 121.5-MHz and 406-MHz frequencies. The ELT was not damaged, and it activated after impact. The signal was received at 1726:51 by the Canadian Mission Control Centre at Trenton, Ontario, and continued transmitting until turned off by maintenance personnel at 1816:29.

1.16 Tests and research

1.16.1 Functional test of fuel system

To determine whether a defect in the gauge system had contributed to the occurrence, a functional test of the aircraft's fuel system was conducted. An examination of the engine nacelle fuel tanks showed that the left tank was intact, and the right one was bent out of shape at its bottom, near the probe. An electrical transmitter mounted vertically in each of the engine nacelle tanks transmits the fuel level to the appropriate gauge.

Both engine nacelle tanks, each with a capacity of 382 pounds, were filled and then progressively emptied to compare the quantity of fuel on board with the quantity shown on the gauges.

While the tanks were being emptied, the left and right NACELLE NOT FULL indicators illuminated when their respective nacelle tanks contained approximately 375 pounds each.

Table 7. Quantity of fuel on board compared to the quantity shown on the gauges

Fuel on board (pounds)	Fuel in left tank (pounds)		Fuel in right tank (pounds)	
	Gauge	Deviation	Gauge	Deviation
348	350	+2	336	–12
305	323	+18	280	–25
261	266	+5	252	–9
217	205	–12	224	+7
173	154	–19	189	+16

130	112	–18	154	+24
86	63	–23	98	+12
42	24	–18	NA*	NA*
24	2	–22	NA*	NA*

* No reading was possible because the tank was bent out of shape.

The test revealed that, at the mid-capacity point, the gauge of the left tank slightly undervalued the actual quantity of fuel, whereas the gauge of the right tank slightly overvalued it.

The 2 transmitters and the 2 gauges were subsequently removed and sent to the TSB Laboratory for technical examination of their components.

1.16.2 Laboratory examination of fuel gauge system components

Examination and testing of the components of the fuel gauge system at the TSB Laboratory showed that, in general, the gauges under-represented the quantities of fuel associated with the occurrence,[35] with no abnormal movement, freezing in place, or sticking of the gauge needles.

Although the examination of the gauge system components revealed only minor specification deviations in their post-accident states, the gauges yielded valid representations regarding the quantity of fuel on board. Of 48 gauge readings taken, the quantity of fuel was under-represented in 45 and over-represented in 3, by up to a maximum deviation of 8 pounds.

1.16.3 Study of general aviation occurrences involving fuel exhaustion

In 2000, the Bureau d'Enquêtes et d'Analyses pour la sécurité de l'aviation civile (BEA) (Bureau of Investigation and Analysis for Civil Aviation Safety) of France carried out a study of occurrences involving fuel exhaustion between 1991 and 2000 in general aviation. The study found that the contributing factors in such occurrences included

- incomplete flight preparation with a minimum amount of fuel;
- lack of familiarity with the aircraft;
- fuelling information not recorded in logbooks or subject to error (for purposes of comparisons between gauge readings and fuelling); and
- obstinacy in extending the flight despite awareness of a low quantity of fuel remaining.[36]

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35 Those quantities ranged between ¾ and ⅛ of tank capacity.

36 Bureau d'Enquêtes et d'Analyses pour la sécurité de l'aviation civile (BEA) de France, *Étude : Pannes d'essence en aviation générale,* available at:

1.16.4 TSB laboratory reports

The TSB completed the following laboratory reports in support of this investigation:

- LP110/2013 – CVR [cockpit voice recorder] Download
- LP154/2013 – Test of fuel quantity measuring system

1.17 Organizational and management information

1.17.1 Aviation Flycie Inc.

At the time of the accident, Aviation Flycie Inc. was a recently formed company. Its owners filed a statement of intent with TC in August 2012 to operate a commercial air service.[37] The company's organization chart showed 2 levels of management. The president occupied the position of operations manager in addition to the role of accountable executive. The chief pilot and the PRM reported directly to the president.

On 26 March 2013, Aviation Flycie Inc. commenced business under CARs Subpart 703 using a single BE10 aircraft. The chief pilot was the company's only pilot-in-command, and had trained the PRM as co-pilot before the company began flight operations. Therefore, when commercial flights were first conducted, the company had 3 employees in operations and a co-founder in sales and administration. A second co-pilot was hired approximately 2 weeks later.

To carry passengers on board the BE10, which is a pressurized turboprop aircraft, operators must hold either an operator certificate issued under Part VII of the CARs or a private operator registration issued under CARs Subpart 604.

1.17.2 Transport Canada Civil Aviation: Regulatory framework

To obtain an operator certificate, applicants must satisfy the following requirements, among others:

> *(a)* maintain an adequate organizational structure;
>
> *(b)* maintain an operational control system;
>
> *(c)* meet training program requirements;
>
> […]
>
> *(f)* conduct the operation safely.[38]

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http://www.bea.aero/etudes/pannes.d.essence/pannes.d.essence.pdf (last accessed 27 August 2015).

37 Transport Canada, Commercial Air Service Statement of Intent 26-0380 (0711-06).

38 *Canadian Aviation Regulations* (CARs) 703.07(1).

In addition, applicants must have:

> *(a)* a management organization capable of exercising operational control;
>
> *(b)* managerial personnel who have been approved by the Minister in accordance with the *Commercial Air Service Standards* [CASS], are employed on a full-time basis and perform the functions related to the following positions, namely,
>
> (i) operations manager,
>
> (ii) chief pilot, and
>
> (iii) maintenance manager [the person responsible for maintenance] […].[39]

The company's appointments of an operations manager, a chief pilot, and a PRM must be approved by TC. As part of the approval process, candidates must pass a written exam and an interview conducted by 2 TC inspectors. They must demonstrate that they possess the knowledge necessary[40] to carry out the duties and responsibilities of their respective management positions. No limit is placed on the number of retakes for the written exam or the interview.

The interview questions vary depending on the type of company and its geographic location. The purpose of these steps is for the candidate to demonstrate sufficient familiarity with the content of the COM, the training manuals, the SOPs, and the CARs provisions and standards to be able to carry out the duties and responsibilities associated with the chief pilot position.

TC does not check the candidate's work history with previous employers. For example, the pilot's past performance during training, exams or flight tests, or performance as pilot, have no bearing on the approval process. If all of the requirements of CASS 723.07 are met, TC, on behalf of the Minister, must approve the appointment, regardless of the candidate's history.

1.17.2.1 *Approval of the operations manager appointment*

According to CASS 723.07(2)a)(i), an operations manager must:

> (A) hold or have held the appropriate licence and ratings which a pilot-in-command is required to hold for one of the aeroplanes operated; or have acquired not less than 2 years related supervisory experience with an air operator of a commercial air service whose flight operations are similar in size and scope;
>
> (B) demonstrate knowledge to the Minister with respect to the content of the *Company Operations Manual*, the Air Operator Certificate and Operations

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39 *Canadian Aviation Regulations* (CARs) 703.07(2).

40 Transport Canada, Policy Letters 140R, issued 01 January 2003, available at: http://www.tc.gc.ca/eng/civilaviation/standards/commerce-policy-pl140r-2110.htm (last accessed 28 September 2015).

> Specifications, the provisions of the regulations and standards necessary to carry out the duties and responsibilities to ensure safety; and
>
> (C) [have] attended a Company Aviation Safety Officer (CASO) course or attends such a course within 12 months of assuming the position of Operations Manager.[41]

The company's president and co-founder, who had completed commercial pilot training in 2010 and had accumulated approximately 300 total flight hours, met the regulatory requirements when applying for the operations manager position. This was the president's first experience as operations manager for an air carrier. The president had no previous work experience in commercial operations and no flight experience on the BE10.

The candidate chosen by Aviation Flycie Inc. successfully completed the written exam and the interview[42] on the first attempt.

1.17.2.2 Approval of the chief pilot appointment

To work for an operator that performed IFR flights, the candidate for the position of chief pilot at Aviation Flycie Inc. was required to:

> (III) […] hold a valid Airline Transport Pilot Licence (Aeroplane) or in the case of an IFR centre line thrust aeroplane or single-engine operation, a valid Commercial Pilot Licence (Aeroplane) and a valid Instrument Rating[…][43]
>
> […]
>
> (I) […] hold a type rating for one of the types of aeroplanes operated;
>
> (II) have at least 500 hours flight time of which 250 hours shall be as pilot-in-command within the preceding 3 years on the same category and class of aircraft being operated;
>
> (III) be qualified in accordance with the air operator's training program to act as a pilot-in-command on one of the types to be operated; and
>
> (IV) demonstrate knowledge to the Minister with respect to the content of the *Company Operations Manual*, Training Manuals, Standard Operating Procedures (if applicable), *Company Check Pilot Manual* (if applicable), and the provisions of the Regulations and Standards necessary to carry out the duties and responsibilities of the position.[44]

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41 *Commercial Air Service Standards* (CASS), subparagraph 723.07(2)a)(i).

42 Transport Canada, Policy Letters 152, available at: http://www.tc.gc.ca/eng/civilaviation/standards/commerce-policy-pl152-2128.htm (last accessed 28 September 2015).

43 *Commercial Air Service Standards* (CASS), division 723.07(2)b)(i)(A).

44 *Ibid.*, division 723.07(2)b)(i)(B).

In addition, according to CASS 723.07(2)b)(i)(C):

> The chief pilot's personal record in relation to aviation shall not include:
>
> (I) any conviction under subsection 7.3(1) of the *Aeronautics Act*; or
>
> (II) two or more convictions, occurring during separate unrelated events, under the *Canadian Aviation Regulations.*[45]

The chronology of TC's approval of the company's chief pilot was as follows:

- On 08 November 2012, the company submitted the chief pilot's application to TC.
- On 16 November 2012, TC certified that the candidate met the requirements.
- On 21 December 2012, the candidate passed the written exam.
- On 22 February 2013, the candidate failed the first interview.
- On 26 February 2013, the candidate passed the second interview.
- On 18 March 2013, the candidate passed the PPC on the BE10, although the PPC showed several weaknesses (section 1.18.1.2).

When the application for approval of the chief pilot appointment was first submitted to TC, the pilot's logbook showed 259 flying hours as pilot-in-command within the preceding 3 years. Since the pilot did not carry out any flights as pilot-in-command between the time when the application was submitted in November and the approval of the appointment in March, over 4 months later, the total flying hours within the preceding 3 years was fewer. Consequently, when approved by TC on 26 March 2013, the pilot had just 216 flying hours as pilot-in-command within the preceding 3 years. The pilot's flying hours were not certified, and no verification of those hours was carried out.

At that point, the pilot was performing the responsibilities of pilot-in-command on the BE10 for the first time in commercial operations.

1.17.2.3 Person responsible for maintenance

CASS 726.03 states, "The person responsible for the maintenance control system [PRM] … should be a member of the air operator's staff."[46]

The candidate for the PRM position was a new co-pilot on the company's BE10 who had obtained a commercial pilot licence in 2010 and a flight instructor rating in 2011, and had logged a total of 300 flying hours. The candidate had no previous experience in maintenance or in air taxi flight operations.

The candidate chosen by Aviation Flycie Inc. successfully passed the written exam and the interview[47] on the first attempt.

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45 *Commercial Air Service Standards* (CASS), division 723.07(2)b)(i)(C).

46 *Ibid.,*section 726.03.

1.17.2.4 Issuance of the company's air operator certificate

An air operator certificate for air taxi operations[48] is issued subject to specific conditions, and remains valid as long as those conditions are met. They stipulate, in particular, that the air operator must carry out air operations in accordance with the COM.

Once the conditions for the issuance of the operator certificate[49] have all been met, the Minister issues the certificate. In the case of Aviation Flycie Inc., the appointment of the managers was the last step required for the issuance. Management appointments are approved individually.

In this case, the combined experience of the candidates, and their lack of experience in commercial IFR operations, was not taken into consideration during the appointment approval process. On 26 March 2013, TC approved the appointments of the operations manager, the chief pilot and the PRM. The letter of approval issued by TC advised the candidates that their credentials, work histories, and experience had been deemed satisfactory.[50] At that point, the chief pilot no longer had the required 250 flying hours as pilot-in-command within the preceding 3 years.[51]

TC issued air operator certificate number 11956 on 26 March 2013.

TC recognized that the combined inexperience of the operations manager, the chief pilot and the PRM, together with the fact that Aviation Flycie Inc. was a start-up company, could constitute risk factors. On 26 March 2013, TC carried out a risk assessment due to the weak performance of the candidate for the position of chief pilot during the approval process. Consequently, TC put measures in place to mitigate the risk associated with the candidate's performance of chief pilot duties, and planned to carry out an oversight activity every 2 months, the first of which was scheduled for 18 June 2013 (section 1.18.1.4).

1.17.2.5 Transport Canada oversight activities

TC carries out both planned and unplanned oversight activities. Planned oversight includes activities carried out at predetermined intervals. Unplanned oversight includes those carried out following an unforeseen problem or occurrence, such as an accident. For companies that are just starting out, TC often carries out an inspection within one year of operation, but there is no firm requirement to do so.

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47 Transport Canada, Policy Letters 152, available at: http://www.tc.gc.ca/eng/civilaviation/standards/commerce-policy-pl152-2128.htm (last accessed 28 September 2015).

48 *Commercial Air Service Standards* (CASS), section 723.07.

49 *Canadian Aviation Regulations* (CARs) 703.09.

50 Transport Canada, Letters of approval of the appointments, 26 March 2013.

51 *Commercial Air Service Standards* (CASS), sub-paragraph 723.07*b)*(i)(B)(II).

One of TC's oversight activities is the process inspection (PI), which consists of reviewing the process that a company uses to produce a result. In PI planning, the inspection team selects a process related to the initial cause that prompted the PI, reviews the process, then reviews the results of the process. If an instance of non-compliance or a situation deemed unsafe is found, TC can take the following measures, either separately or concurrently:

1. Request a corrective action plan;
2. Evaluate punitive measures for enforcing the *Aeronautics Act*; or
3. Take certificate action, which involves suspension or cancellation of a Canadian aviation document (CAD),[52] especially for a finding of immediate threat to aviation safety.[53]

TC's initial approach is to involve the company and provide assistance to analyze the situation, identify deficiencies, and implement the necessary corrective measures.

1.17.2.6 Staff instructions

TC inspectors are guided in the performance of their duties by a number of staff instruction documents.

1.17.2.6.1 Staff Instruction No. SUR-014

Staff Instruction No. SUR-014, *Suspension or Cancellation of Canadian Aviation Documents for Safety Reasons*, is intended "to provide guidance […] in the application of sections 7.(1)[54] and 7.1(1)[55] of the *Aeronautics Act* (the Act) as they relate to certificate action […]."[56]

In the first application (threat to aviation safety or security),

> a *threat* is defined as a condition that is likely to pose a risk of injury, death, or significant property damage, as a result of an aircraft accident. An *immediate threat* to aviation safety is a threat to the safety of an aircraft that currently exists or is about to exist, and creates a reasonable expectation that unless immediate action is taken to neutralize the threat, death, injury or significant damage to property is imminently likely.[57]

According to SUR-014,

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52 "[…]any licence, permit, accreditation, certificate or other document issued by the Minister […] to or with respect to any person or in respect of any aeronautical product, aerodrome, facility or service." (Source: *Aeronautics Act*)

53 *Aeronautics Act*, Sections 6.9 through 7.21.

54 Threat to aviation safety or security.

55 Safety reasons other than a situation that poses an immediate threat to aviation safety.

56 Transport Canada, Staff Instruction No. SUR-014, *Suspension or Cancellation of Canadian Aviation Documents for Safety Reasons*, (July 2011), paragraph 1.1 1).

57 *Commercial Air Service Standards* (CASS), paragraph 4.1 1).

> TCCA inspectors considering suspension of a CAD under section 7. of the Act [immediate threat] must:
>
> a) verify the nature of the threat to aviation safety; and
>
> b) verify that the threat to aviation safety is immediate, and that a suspension of the CAD is necessary for the purpose of preventing and eliminating the danger or risk of injury, death, or significant property damage […].[58]

In the second application (safety reasons other than a situation that poses an immediate threat to aviation safety), "the urgent need to cease the activity in response to an identified, specific, and immediate threat to aviation safety is not present."[59] Other safety reasons for suspension or cancellation of a CAD are the following:

> *a)* the holder of the document is incompetent;
>
> *b)* the holder […] ceases to meet the qualifications necessary for the issuance of the document […]; or
>
> *c)* the Minister is of the opinion that the public interest […]warrant[s] it.[60]

According to SUR-014, "incompetence is the inability to perform activities that are authorized in a CAD in compliance with the regulations and standards applicable to that type of activity."[61] To establish incompetence, "an assemblage of evidence that collectively demonstrates an inability to comply, over a reasonably lengthy period of time"[62] must be compiled. Thus, the "decision to take certificate action related to incompetence […] must be supported by an abundance of evidence that indicates a CAD holder is not only non-compliant, but that they are unable to comply with the regulatory requirements […]."[63]

In such a situation, inspectors are advised that "it is important to ensure sufficient evidence exists to support any decision, and the evidence relates specifically to the reason cited for the certificate action […]."[64]

To invoke public interest,

> evidence must be available to specifically show or demonstrate how the public interest is served by the certificate action. If the certificate action is

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58 *Ibid.*, paragraph 4.1 9).

59 *Ibid.*, paragraph 5.1 3).

60 *Aeronautics Act*, Section 7.1(1).

61 Transport Canada, Staff Instruction No. SUR-014, *Suspension or Cancellation of Canadian Aviation Documents for Safety Reasons*, (July 2011), paragraph 5.4 3).

62 *Ibid.*

63 *Ibid.*, paragraph 5.4 5).

64 *Ibid.*, paragraph 5.1 2).

> based on an aviation record, the evidence must include the aviation records being used to support the decision for certificate action.[65]

In all cases,

> the burden of proof for providing adequate justification for the particular certificate action taken falls upon the Minister. The Minister must prove on the balance of probabilities […] that certificate action is warranted.[66]

1.17.2.6.2 Staff Instruction No. SUR-015

Staff Instruction No. SUR-015, *Refusal or Revocation of Non-Canadian Aviation Document Ministerial Approvals*, describes the process for refusing or revoking ministerial approvals, such as approvals of operations management personnel.

According to SUR-015, the CASS standards

> contain […] no subjective criteria that would constitute grounds for refusal of the approval, nor do the regulations elaborate under what conditions such approvals be refused or revoked. […] Any decisions to refuse or revoke an approval of one of the specified managerial personnel must be based on the specified qualifications stipulated in the [standards]. [Consequently,] using criteria for deciding to refuse or revoke an approval, other than an objective assessment of the qualification requirements established in the [CARs standards] is not appropriate.[67]

SUR-015, which is used in ministerial approvals, contains no provision for refusing or revoking an approval in cases of immediate threat, incompetence, or public interest. Moreover, the processes set out in SUR-015 are "not intended to address a circumstance where a person appointed to one of the regulation-specified managerial positions is found not to be performing the functions related to the position."[68]

Finally, SUR-015 reminds inspectors that

> Subparts 703, 704 and 705 of the CARs require the Minister to issue an air operator certificate when the applicant for the certificate has (among other things) managerial personnel who have been approved by the Minister in accordance with the [CARs standards]. [Thus, the CARs standards] stipulate

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65 Transport Canada, Staff Instruction No. SUR-014, *Suspension or Cancellation of Canadian Aviation Documents for Safety Reasons*, (July 2011), paragraph 5.6 2).

66 *Ibid.*, paragraph 5.1 4).

67 Transport Canada, Staff Instruction No. SUR-015, *Refusal or Revocation of Non-Canadian Aviation Document Ministerial Approvals*, (July 2011), paragraph 4.1 1).

68 *Ibid.*, paragraph 4.1 3)(b), Note.

> […] qualifications that are essentially a cumulative list of objective conditions that individuals must meet in order to be approved by the Minister.[69]

1.18 *Additional information*

1.18.1 *Pilot proficiency check of the chief pilot*

To pass a PPC, a candidate's performance must meet acceptable standards as per the performance criteria stipulated by TC.[70] In addition, to be eligible for the PPC, the candidate must submit a series of documents and have undergone the required training.

1.18.1.1 *Flight training in preparation for the pilot proficiency check*

Before taking the PPC, the chief pilot had received flight training as preparation. The training took place between 13 and 18 March 2013, and involved 5 training flights on the company's BE10 accompanied by a contract training pilot, for a total of 8.9 flying hours. During those flights, the chief pilot practised the checklist procedures for normal, abnormal, and emergency situations. During this training, the chief pilot's performance was inconsistent and flying skills were deemed to be either below standard, or marginal.

1.18.1.2 *Aircraft pilot proficiency check (BE10)*

On 18 March 2013, the pilot underwent an initial aircraft PPC that met the requirements for an instrument rating as pilot-in-command on the BE10, and passed. Single-pilot, multi-crew, and area navigation (RNAV) exercises were carried out. The pilot was seated on the left, and the training pilot who had trained the pilot-in-command acted as co-pilot.

The flight test was carried out by a TC inspector who was an approved check pilot (ACP). Given the small size of the aircraft, there was no jump seat in the cockpit. Therefore, the ACP observed the crew's actions and the instruments from a position slightly to the rear, in the cabin.

Supervising a PPC from the passenger seat behind the pilots restricts the view of the cockpit and limits the monitoring of communications. In a situation where the test exercises are carried out at higher altitude, free of the operating constraints associated with ATC, the ACP can, to a reasonable extent, observe the candidate's performance while taking notes.

However, when the exercises are carried out at the limits of acceptable performance, with some needing to be repeated, the ACP's workload increases significantly. The ACP has little time in which to assess the performance against the acceptable limit of the criterion, to decide

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[69] Transport Canada, Staff Instruction No. SUR-015, *Refusal or Revocation of Non-Canadian Aviation Document Ministerial Approvals*, (July 2011), paragraph 4.1 1).

[70] Transport Canada, TP 14727, *Pilot Proficiency Check and Aircraft Type Rating Flight Test Guide* (2007).

whether or not to repeat the exercise, and to determine a score for the exercise, all the while writing down the deviations and comments.

In this PPC, the pilot's performance bordered on failure,[71] as the ACP entered 4 scores of "2" on the flight test report of the following exercises:

Table 8. Notes written by the approved check pilot on the flight test report of the chief pilot's pilot proficiency check

Exercise No.	Description	Comments
1.	Technical knowledge	Limited technical knowledge.
11.	Steep turns	Significant altitude deviation of ±150 feet, noticed within an acceptable length of time and corrected. The safety of the flight was not compromised.
16.	RNAV approach	Altitude deviation noticed by the pilot monitoring, corrected within an acceptable length of time.
17.	Go-around	During the go-around procedure with one engine, the candidate did not establish the aircraft at the blue line [single-engine best rate-of-climb speed, 119 knots] but maintained 160 KIAS.

The candidate was first assessed as part of a crew[72] and then as a single pilot with no assistance from the co-pilot. The actual flying time of this PPC, including the time spent repeating steep turns, was one hour. It was not possible to carry out a precision approach opposite to the runway in use, due to traffic at the time of the test.

During the second approach carried out in single-pilot operations, the co-pilot called out "Altitude" to prevent a descent below minimum descent altitude (MDA). When that callout was made, the ACP was distracted by note-taking and was unable to observe the execution of the level-off or to observe any potential deviation below the MDA. Therefore, the ACP could not determine whether the candidate had in fact descended below MDA, which would have constituted a failure. The candidate received a score of "2" for this part of the test.

The ACP has the option of repeating any component or manoeuvre of the PPC, including in "any condition where the ACP was distracted to the point that the candidate's performance of the manoeuvre (radio calls, traffic, etc.) could not adequately be observed."[73]

A pilot who fails a PPC must receive additional training before another attempt; however, TC places no limit on the number of times a PPC is retaken. The operations manager was

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71 A total of 5 scores of "2" during a pilot proficiency check constitutes a failure.

72 The candidate is assessed as pilot flying, and then as pilot not flying.

73 Transport Canada, TP 6533, *Approved Check Pilot Manual*, 9th edition (2007), p. 27.

made aware of the weak performance of the chief pilot. However, no further action was considered since the PPC was passed.

1.18.1.3 Concerns regarding the chief pilot's proficiency check

On 19 March, the day after the PPC, the TC ACP who was responsible for the flight test sent a letter to the inspectors responsible for Aviation Flycie Inc. to express concern about the appointment of the company's chief pilot. The ACP considered the concern to be warranted due to the low level of technical knowledge demonstrated by the chief pilot during the 2 interviews that were needed for the approval of the appointment, and due to marginal performance during the PPC. In particular, the letter pointed to unsolicited assistance provided by the pilot not flying during the single-pilot portion of the test.

According to the ACP, the chief pilot's weaknesses could compromise the tasks for which the chief pilot position was responsible (i.e., training and supervision of pilots and co-pilots, and administration of co-pilot competency checks). The letter also cited potential for increased risk to flight safety in the event that the chief pilot were to undertake a flight with a co-pilot who had little experience.

The letter concluded by suggesting that TC carry out a risk assessment before issuing an operator certificate to Aviation Flycie Inc., that it pay special attention to the company's overall operations and, in particular, that it review its granting of Operation Specification 011 (which authorizes the use of an aircraft for IFR flight with passengers on board and no co-pilot).

1.18.1.4 Risk assessment by Transport Canada

On 26 March 2013, the person responsible for issuing the certificate and the senior operations inspector responsible for Aviation Flycie Inc. carried out a risk assessment based on the chief pilot's low level of knowledge and skills.

Staff Instruction No. QUA-008 sets out methods of analysis that can be used in such risk assessments to identify appropriate mitigation measures, depending on the complexity of the issues. A basic risk assessment tool was used to analyze the risks associated with the appointment of the chief pilot. The tool is aimed at assessing simple issues within a reasonable length of time, and "[…] also may serve to perform due diligence in support of decision-making."[74]

The assessment found that conditions at the company were conducive to inappropriate application of the training program, leading to inadequate training that would result in failure by the company's pilots.

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[74] Staff Instruction No. QUA-008, *Risk Management Process for Aviation Safety Activities*, 7.3 The Basic Tool 1) b).

After assessing the probability and severity of the risk, TC estimated the level of risk to be low to medium (Appendix B).[75] The risk scenario was considered likely to materialize, and the consequences of the risk were considered to be negligible.

The assessment concluded that the following measures could be used to mitigate the risks that had been identified:

1. A program of preplanned PIs (aimed at the training program, operational flight plans, and flight duty times);
2. Pilot competency checks (PCC) to be administered by TC for at least one year;
3. Open communication with the operations manager.[76]

The operations manager was not informed of the concerns expressed by the TC ACP or that a risk assessment stemming from the weaknesses of the chief pilot candidate had been carried out. As TC was not required to inform the operations manager of internal activities associated with the approval of the chief pilot's appointment, no formal document to that end was sent to the company.

Subsequently, TC planned a PI, to be carried out on 18 June 2013.

1.18.1.5 Process inspection of 18 June 2013

On 18 June 2013 (8 days after the accident), TC carried out a PI of the company's training program and operational control since 26 March 2013, the date of issue of the company's operator certificate. The PI focused on

- the company's training program, by reviewing all training records to determine whether the program was being carried out properly;
- its flight records, by reviewing operational flight plans to determine whether flight records were properly kept; and
- its pilot flight times and flight duty times, by reviewing flight time and duty records to determine whether they were properly monitored.

Among the objectives of the PI was to verify that the processes identified were functioning as intended and that the applicable regulatory requirements were met. The inspection team found just one non-compliance with regulations: discrepancies related to examination questions on area navigation (RNAV) and on in-flight icing were identified. Consequently, all pilots were required to retake those exams and have them corrected before carrying out further commercial flight. The company made a commitment to have the pilots retake those exams and to have the chief pilot carry out a verification of all of the exams twice a year.

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[75] The risk indicator granted was 4A according to the risk measurement form used by Transport Canada during the risk assessment.

[76] Transport Canada, *Risk assessment No. GR13-010*, 26 March 2013.

After the accident involving C-GJSU, Aviation Flycie Inc. took steps to use a new aircraft, a Beechcraft C90 King Air, which would be based at the Sept-Îles Airport (CYZV), Quebec. Accordingly, TC was asked to carry out PPCs on 2 new pilots based at CYZV. Because the new Beechcraft C90 King Air was a different aircraft type from the occurrence BE10, the chief pilot was required to undergo training and a PPC on that type before acting as captain of a commercial flight or giving training.

On 09 July 2013, TC inspectors went to Sept-Îles to carry out PPCs for the 2 pilots recommended by the chief pilot. The inspectors found that the chief pilot had provided training without being qualified on the new aircraft type, and that one of the pilots had not completed the required training.

1.18.1.6 TSB examination of company records

After receiving its operator certificate, the company carried out 41 commercial flights using C-GJSU, and the chief pilot was the pilot-in-command on all of those flights. A review of flight records revealed that 26 flights had been non-compliant with existing regulations. The non-compliances were in the following areas:

- Training
  - 1 aircraft competency check of a co-pilot had been carried out with passengers, who included the operations manager, on board.[77]
- Fuel
  - 14 flights had commenced without the quantity of fuel required by the COM.
  - 11 flights had landed at their destinations without having the fuel reserves required on landing:
    - 5 did not have the required 45-minute reserve;
    - 3 did not have the fuel required to reach the alternate airport;
    - 3 had less than 25 minutes of fuel at time of landing (19, 21, and 22 minutes, respectively).
- Weight and balance
  - 3 flights had been outside of weight-and-balance limits.
  - 10 flights had been recorded as having over 500 pounds of fuel for taxiing, whereas C-GJSU normally uses between 40 and 75 pounds.
  - The segmented weights indicated in the COM were not used to calculate the weights of the passengers.

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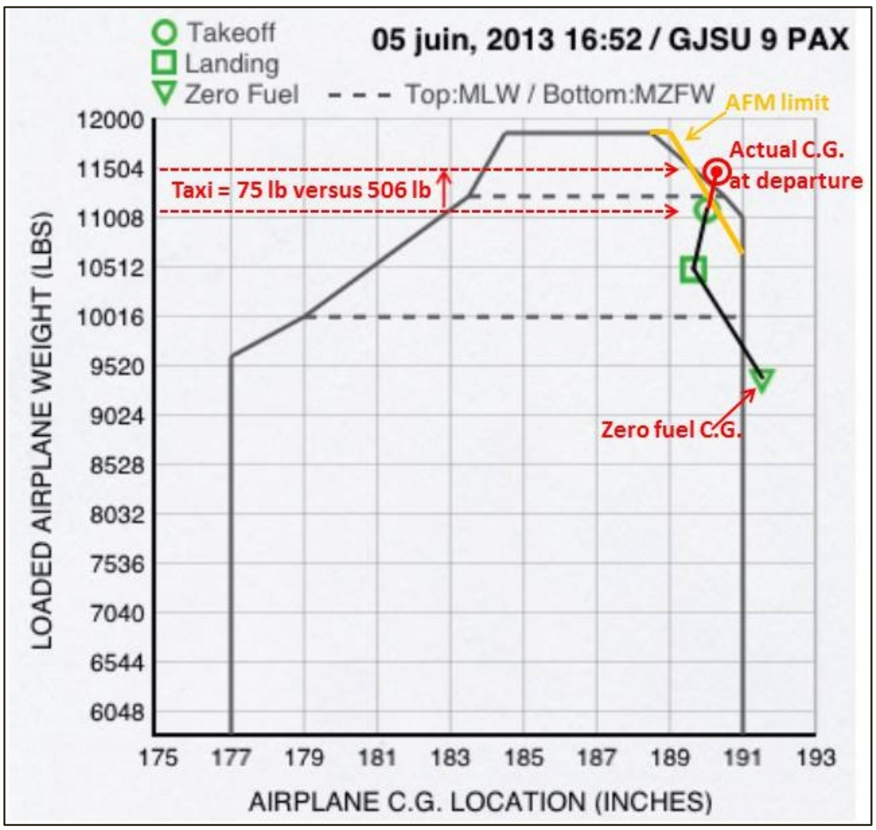
[77] *Canadian Aviation Regulations* (CARs) 703.26 stipulates "No person shall, where passengers are on board an aircraft, simulate emergency situations that could affect the flight characteristics of the aircraft."

  - The TC-approved weight-and-balance form included an incorrect upper limit for centre of gravity (between 189 and 191 inches). According to the limits published in the AFM, the upper limit of the envelope should follow the yellow line shown in Figure 7.
- Crew
  - 8 flights had been carried out with a co-pilot who had been assigned to a series of IFR flights with passengers, even though that individual had not completed the ground training, the flight training, or the PCC. Furthermore, the company did not have the required Operations Specification 011.[78]

Figure 7. Weight-and-balance envelope for C-GJSU (Source: Aviation Flycie Inc., weight-and-balance form, with TSB annotations)



Companies develop policies and procedures (published in a COM and as SOPs) that are aimed at setting safe limits for operations. However, some pilots, in order to be more productive or to derive other benefits, do not stay within those limits. When repeated over

78 Operations Specification 011 authorizes use of the aircraft in IFR flight with passengers on board and no co-pilot.

time, this variance results in adaptations to the procedures and in deviations from prescribed limits, leading to unsafe practices.[79]

Normally, these procedural adaptations do not have visible and immediate adverse consequences. The threats to safety that they pose are not obvious, because the violations of procedures or regulations do not immediately lead to an accident. Moreover, the fact that these flights have been successfully carried out without incident can encourage pilots to continue deviating from regulatory limits.

Without supervision, education, or enforcement of prescribed limits on a regular basis, some people will tend to keep on adapting the procedures and taking shortcuts until they reach the limits of an unsafe situation during an accident.

1.18.2 Company operations manual

The COM provides guidance to personnel in the performance of their duties during commercial flights in accordance with the company's policies and requirements.

1.18.2.1 Duties and responsibilities of the operations manager

The operations manager is responsible for overseeing the safety of air operations. According to the COM, the duties and responsibilities of the operations manager include

- monitoring the operations and operating standards of all aircraft used;
- supervising crew schedules and training;
- verifying the qualifications of flight crew members;
- ensuring that crew schedules comply with regulations regarding flight time and flight duty time;
- ensuring that aircraft take off in compliance with their weight-and-balance limits; and
- ensuring that the company complies with existing regulations.

1.18.2.2 Duties and responsibilities of the chief pilot

The chief pilot is responsible for issues related to the professional standards of subordinate flight crews. Specifically, the chief pilot must

- approve the SOPs;
- approve or carry out flight crew training;
- supervise flight crews; and
- carry out duties as delegated by the operations manager.

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79 J. Rasmussen, "Risk management in a dynamic society: a modeling problem," *Safety Science*, volume 27, issue 2/3, 1997, 183-213, p. 197.

1.18.2.3 Regulatory fuel requirements

Given that the occurrence flight took place during daylight hours under VFR, the aircraft was required to carry enough fuel to enable it to fly to the destination aerodrome and to continue flight for 30 additional minutes at normal cruising speed.[80]

1.18.2.4 Aviation Flycie Inc.'s fuel requirements

The company's fuel requirements, specified in Chapter 3 of the COM, were more stringent than those of the CARs when a flight is a VFR flight. Whereas the CARs require only 30 minutes of reserve fuel for VFR flights, the COM required 45 minutes.

Generally, no flight, whether VFR or IFR, is allowed unless the aircraft carries a sufficient quantity of fuel to enable it to fly to the destination aerodrome, to make an approach and a missed approach there, to continue the flight to the alternate aerodrome and land there, and to continue the flight for an additional 45 minutes (Appendix A).

1.18.2.5 Notice regarding minimum fuel

The phrase MINIMUM FUEL is used to refer to a situation in which the remaining quantity of fuel on board has become such that the aircraft must land at a specific aerodrome, and cannot experience any additional delays. The pilot should advise ATC as soon as a MINIMUM FUEL situation arises. Use of this phrase does not mean that there is an emergency, but rather that an emergency is possible should an unforeseen delay occur.

Flight priority is granted to a pilot who declares a fuel emergency by broadcasting MAYDAY MAYDAY MAYDAY FUEL.

The use of such standardized terms makes it possible to distinguish between a minimum fuel situation and a fuel emergency, and makes the pilot's intentions clear to ATC with no need for further confirmation.

1.18.2.6 Minimum crew

According to Section 3.7 of the COM, under Operations Specification 011, the minimum crew is one pilot. Operations Specification 011 is issued under CARs 703.86(a). The use of an aircraft for an IFR flight with passengers on board and no second-in-command (co-pilot) is authorized when using the types of aircraft indicated by reference numbers and listed in Section 2 of this operations specification; the specification is valid if the air carrier complies with the requirements of CASS 723.86.

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80 *Canadian Aviation Regulations* (CARs) 602.88.

Aviation Flycie Inc. did not hold Operations Specification 011 at the time of the accident. Consequently, the company could not operate its aircraft with passengers on board under IFR with fewer than 2 qualified pilots.

1.18.2.7 Flight preparation at Aviation Flycie Inc.

An electronic tablet or a computer was used by the company for flight preparation. Aviation Flycie Inc. provided each flight crew member with an electronic tablet that contained 4 applications:

- Aviation W&B: used to calculate weight and balance
- ForeFlight: used for flight planning and weather analysis
- FltPlan.com: used to fill out and submit a flight plan
- SignNow: used to fill out and submit a flight authorization form.

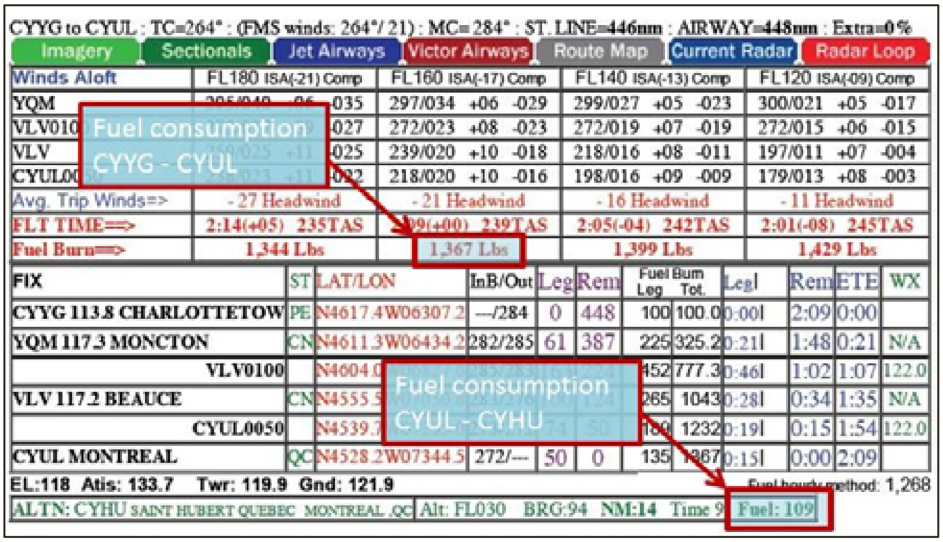
Before undertaking a flight, the crew must complete an operational flight plan, a weight-and-balance report, and a flight authorization form. These were normally reviewed by the operations manager.

1.18.2.7.1 Operational flight plan

The Web service FltPlan.com was used to create the operational flight plan, using calculations based on C-GJSU performance specifications and on the winds forecasted at the time of the flight. The operational flight plan provided the following information:

- an ATC flight plan;
- a calculation of the fuel quantity required to fly to the destination airport and to the alternate airport;
- turning points with time en route and quantities of fuel used;
- some additional information; and
- space to note down the time of departure and time of arrival.

Figure 8. Calculation of fuel requirements (Source: FltPlan.com, with TSB annotations)



The fuel reserve quantities were not included in the operational flight plan, and the total quantity of fuel required before departure was not shown (Figure 8). In addition, no boxes were provided in which to record, over time, the remaining quantities of fuel as specified in the CASS.[81]

The flight plan submitted to ATC for the 09 June 2013 flight from CYYG to CYUL indicated a flight time of 2 hours 17 minutes. However, the operational flight plan in the company's records was dated 11 June 2013, with a flight time of 2 hours 9 minutes.

According to the calculations in the operational flight plan, C-GJSU's fuel consumption between its departure from CYYG and its arrival at CYUL was projected to be 1367 pounds, with an additional 109 pounds to reach the alternate airport. Therefore, upon departure from CYYG, C-GJSU required 1966 pounds of fuel.[82]

According to the calculations in the operational flight plan, C-GJSU's fuel consumption between its departure from CYUL and its arrival at CYHU was projected to be 192 pounds, with an additional 109 pounds to reach the alternate airport. Therefore, upon departure from CYUL, C-GJSU required 750 pounds of fuel.[83]

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81 *Commercial Air Service Standards* (CASS), paragraph 723.18(3)(c).

82 Including 40 pounds for taxiing and 450 pounds for the 45-minute reserve.

83 Including 40 pounds for taxiing and 450 pounds for the 45-minute reserve.

1.18.2.7.2 Weight-and-balance form

The weight-and-balance calculation was done using an application that runs on a tablet. One copy of the calculation was kept on the pilot's tablet, and another was sent to the company's e-mail address so that it could be available on the co-pilot's tablet.

The segmented weights are used to compute the weight and balance of aircraft whose type certificate authorizes between 5 and 11 passengers, in order to increase the probability that the actual weight would not exceed average weights.[84] The segmented weights are determined based on the number of seats on board the aircraft and take into consideration weight differences between men and women.[85] However, according to TC AIM, "Segmented weights should be used only when actual weights are not available or cannot be implemented."[86]

Although TC AIM recommends using actual weights if they are available, the COM stipulated that segmented weights were to be used, and the air operator was required to comply with the COM, which was approved by TC. The chief pilot did not use segmented weights to compute passenger weight.

1.18.3 In-flight training on the BE10 and dealing with emergencies

Flight training on the BE10 was carried out exclusively on C-GJSU; Aviation Flycie Inc. did not train its pilots on a flight simulator, and regulations did not require it to do so. Consequently, some emergency procedures could not be practised, others were cut short, and some checklist items were not performed. For example, the propellers were not feathered during engine failure exercises.

Simulator training makes it possible, among other things, to optimize the performance of multi-pilot crews in abnormal and emergency situations, while including overall emergency management through task prioritization. Moreover, simulator training provides an opportunity to learn to recognize signs of various abnormal and emergency situations. The possibility of dealing with more emergencies in a simulator reinforces the use of checklists and promotes memorization of vital procedural actions. Because it provides an environment exempt from the real-world constraints of air traffic and ATC, simulator training allows pilots to practise use of standard emergency phraseology (i.e., PAN and/or MAYDAY).

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84 Transport Canada, TP14371, *Transport Canada Aeronautical Information Manual* (TC AIM), Section 3.5.6 of the CARs chapter.

85 Weight data obtained based on the Canadian Community Health Survey (CCHS), Cycle 2.1, published in 2003 and conducted among 130 000 Canadians.

86 Transport Canada, TP14371, *Transport Canada Aeronautical Information Manual* (TC AIM), sub-paragraph 3.5.7d)(i) of the CARs chapter.

1.18.4 *Operational control of Aviation Flycie Inc. flights*

Aviation Flycie Inc. used a Type D operational control system, whereby "Operational control is delegated to the pilot-in-command of a flight by the operations manager who retains responsibility for the day-to-day conduct of flight operations."[87]

According to the COM, flight authorization consisted of reviewing all relevant information and preparations to ensure the safety of passengers and crew. Each flight was authorized by the operations manager or by the pilot-in-command. Therefore, if pilots authorized their own flights, no cross-check was performed on the flight information or flight planning.

According to the COM, to ensure a maximum level of safety, flight preparation must be carried out by the pilot-in-command, assisted by the co-pilot. When flights were carried out by the chief pilot, the co-pilot performed the aircraft's preflight check, but did not participate in calculating the quantity of fuel required for the flight. Instead, the chief pilot would perform the flight planning independently, authorize the flight with no cross-checks, and send the documents to the operations manager, who would file them in the company's electronic records.

1.18.5 *TSB Watchlist*

1.18.5.1 *Safety management and oversight are on the 2014 Watchlist*

The TSB Watchlist contains the issues that pose the greatest risk to Canada's transportation system; by making it public, the TSB aims to focus the attention of industry and regulators on the problems that need addressing today.

The 2014 Watchlist recognizes that some transportation companies are not effectively managing their safety risks, and that TC oversight and intervention have not always proven effective at changing companies' unsafe operating practices. To address this issue, the Watchlist proposes that:

> Transport Canada […] implement regulations requiring all operators in the air […] [industry] to have formal safety management processes. And Transport Canada must oversee these processes.
>
> In all transportation modes, those companies that do have an SMS [safety management system] must, in turn, demonstrate that it is working—that hazards are being identified and effective risk mitigation measures are being implemented.
>
> Finally, when companies are unable to effectively manage safety, Transport Canada must not only intervene, but do so in a manner that succeeds in changing unsafe operating practices.[88]

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[87] *Commercial Air Service Standards* (CASS), paragraph 723.16(1)(b).

1.18.6 Computation of the rate of descent with two engines shut down

At the TSB's request, Beechcraft[89] carried out performance calculations in order to determine the vertical speed of the occurrence aircraft according to various flight parameters. When engine failure occurs on a twin-engine aircraft, the propellers generate significant drag if they are not feathered. The landing gear also creates significant drag. Table 9 shows the result of the rate-of-descent computation.

Table 9. Rate of descent and glide ratio when gliding with no flaps

Propellers feathered	Landing gear	Rate of descent (feet/minute)	Glide ratio
2	Retracted	976	12:1
1	Retracted	1762	7:1
0	Retracted	2547	5:1
0	Down	3046	4:1

1.18.7 Gliding and the aircraft's glide ratio

The glide ratio is the ratio between the distance travelled and the altitude lost to cover that distance, thus measuring the aircraft's gliding capability. The higher the glide ratio, the greater the distance travelled from a given altitude. Drag is the force that has the greatest impact on the glide ratio. Consequently, any condition that increases drag reduces the aircraft's glide ratio.

The glide ratio is reduced by landing gear, flaps, unfeathered (windmilling) propellers, and a speed above or below the best glide speed.

At a speed of 120 knots, with both propellers feathered and the wheels and flaps retracted, C-GJSU had a glide ratio of 12:1. Under these conditions, from a height of 0.5 nm (3040 feet), the aircraft would have been able to travel 6 nm. However, if the propellers were not feathered, the glide ratio would have dropped to 5:1 and, from the same height, C-GJSU would have been able to travel only 2.5 nm.

The manoeuvring room for extending the glide is limited to reducing drag. To that end, the minimum drag speed when gliding is not published; however, the pilot can rely on the vertical climb speed in the event of engine failure. On the speed indicator, this speed is represented by a blue line at 119 knots and, for C-GJSU, was valid at the maximum take-off

88 Transportation Safety Board of Canada, *Watchlist 2014*, Safety management and oversight, available at: http://www.bst-tsb.gc.ca/eng/surveillance-watchlist/multi-modal/2014/multimodal.asp (last accessed 28 August 2015).

89 Textron Aviation.

weight. Based on the actual weight of C-GJSU at the time of the occurrence (approximately 7800 pounds), that speed was 110 knots. Flying at a speed lower than that maximum glide ratio speed would have increased the drag, and consequently reduced the glide ratio.

When gliding, the point on the ground that stays fixed in the windshield represents the point where the aircraft will reach the ground. When the pilot chooses a spot, the movement of that spot in the windshield helps the pilot determine whether the aircraft will reach it or not. If the spot moves lower in the windshield, the aircraft will arrive higher, and if it moves higher, the aircraft is too low to reach that spot.

If the aircraft is above the desired glide path, the pilot can increase the drag, but if the aircraft is below the glide path, the pilot has no other options if the drag is at minimum and the speed is already at best glide speed.

1.19 Useful or effective investigation techniques

Not applicable.

2.0 Analysis

2.1 Introduction

During a local test flight carried out by the company's chief pilot, C-GJSU ran out of fuel after 24 minutes of flight. The resulting glide ended in an aerodynamic stall and collision with the ground just short of the selected landing field.

Examination of the wreckage showed that there was no fuel on board, that the engines were producing no power, and that the propellers were not feathered at the time of impact. Neither the examination of the engines nor that of the fuel system found any defect that could have caused premature fuel exhaustion, failure to supply fuel to the engines, or inaccurate readings on the fuel gauges.

Weather conditions did not play a role in the accident. The pilot had received the required ground training and in-flight training, and had passed a pilot proficiency check (PPC) on the BE10 less than 3 months before the day of the accident.

Apart from the fuel exhaustion, the investigation revealed deficiencies in the pilot's performance and in the company's supervision of flights. The investigation also identified weaknesses in the process used by Transport Canada (TC) to approve appointments of operations management personnel by operators and in the regulatory oversight of flight operations.

Therefore, the analysis will focus on the following items:

- flight planning;
- the quantity of fuel on board at the time of departure from Montréal/St-Hubert Airport (CYHU), Quebec;
- the pilot's handling of the emergency;
- the company's supervision of flights;
- TC's process for the approval of the selection of operations management personnel by companies; and
- TC's regulatory oversight.

2.2 Flight planning

Flight planning for multiple flights makes it possible to, among other things, determine the quantity of fuel required by regulation for each flight and to draw up a fuelling plan. According to the company operations manual (COM), for both visual flight rules (VFR) and instrument flight rules (IFR) flights, the aircraft must carry enough fuel to enable it to fly to the destination aerodrome, to conduct an approach and a go-around there, to continue the flight to the alternate aerodrome and land there, and to continue the flight for an additional 45 minutes.

2.2.1 Planning of the flights that preceded the occurrence flight

Although the operations manager was responsible for day-to-day operations, operational control over the company's flights was delegated to the pilot-in-command. As a result, the pilot was solely responsible for planning the series of flights between Charlottetown Airport (CYYG), Prince Edward Island, and Montréal/St-Hubert Airport (CYHU), Quebec, with a stop at the Montréal/Pierre-Elliott-Trudeau International Airport (CYUL), Quebec.

The operational flight plan used by the company showed only the quantity of fuel needed to reach the destination airport and the alternate airport. The pilot must add these fuel quantities to the quantities required for taxiing, the minimum 45-minute reserve, and all other reserves to determine whether the aircraft complies with the minimum quantity of fuel required by the COM. The total quantity of fuel required is not shown in the operational flight plan, and the *Commercial Air Service Standards* (CASS) do not require it. If the total fuel quantity required for a flight is not calculated and clearly displayed on the operational flight plan, there is an increased risk that aircraft will depart without the fuel reserves required by the *Canadian Aviation Regulations* (CARs).

Using the data from the operational flight plan and adding the quantities required by the COM, 1966 pounds of fuel were required when the aircraft departed CYYG to fly to CYUL. A few hours before departure, the pilot had 527 pounds of fuel added, bringing the total quantity on board to 1860 pounds. Consequently, when it departed CYYG, C-GJSU did not have the quantity of fuel required by the COM for the first leg of the flight to CYUL. If flights are planned and carried out without the fuel reserves required by the CARs, there is an increased risk of fuel exhaustion resulting from unanticipated situations that extend the duration of the flight.

To avoid refuelling when arriving at CYUL, it was necessary to determine the quantity of fuel required for the next leg's departure from CYUL and then add the expected fuel consumption to reach CYUL. Since 750 pounds were required at the time of departure from CYUL and, according to the operational flight plan, 1467 pounds would be consumed to reach CYUL, C-GJSU needed to have at least 2217 pounds when it departed from CYYG to carry out the 2 flights to CYHU without refuelling at CYUL.[90]

Since there were 1860 pounds of fuel on board when the aircraft departed CYYG and the expected fuel consumption was 1467 pounds, it was foreseeable that C-GJSU would arrive at CYUL with less than 450 pounds of fuel (i.e., fuel for less than 45 minutes of flight). Landing under IFR with less than 45 minutes of fuel does not comply with the minimum fuel requirements of either the COM or the CARs.

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90 Including fuel for taxiing: Charlottetown Airport (CYYG), Prince Edward Island, 40 pounds, Montréal/Pierre-Elliott-Trudeau International Airport (CYUL), Quebec, 20 pounds at arrival and 40 pounds at departure.

The data available during the planning of these 2 flights were unambiguous; it was not possible to carry out these flights in accordance with the COM. The pilot's decision to fuel C-GJSU in order to have a total of 1860 pounds of fuel at CYYG showed deficient planning.

2.2.2 Continued flight without required fuel reserves

The flight from CYYG to CYUL lasted 2 hours 36 minutes (i.e., 27 minutes longer than the 2 hours 9 minutes expected during flight planning). Since the pilot made no provision during flight planning for an additional fuel reserve for unforeseen events, C-GJSU landed at CYUL with a lower fuel reserve than that required by the CARs.

Flights sometimes take longer than planned because of operational contingencies; therefore, the quantity of fuel remaining upon arrival at destination can be less than that expected during flight planning. However, if during planning the pilot allows no fuel reserves for dealing with unforeseen events, there is a risk of having to consider diverting to an airport enroute to avoid arriving at the destination with no reserves, or possibly, without enough fuel to reach an alternate airport. Keeping track of fuel consumption during the flight should have alerted the pilot that the destination could not be reached because the aircraft did not have the required reserves. If pilots elect to extend flight without first determining whether sufficient fuel reserves are available to do so, there is an increased risk of fuel exhaustion.

2.2.3 Planning of the occurrence flight

Aviation Flycie Inc. had adopted a more stringent fuel policy for VFR flights than that required by the CARs, and required an alternate airport for all flights. As such, the minimum quantity of fuel for the occurrence flight was 800 pounds.[91]

Because the occurrence flight was carried out in order to conduct in-flight tests, it was considered by the pilot to be a private flight. However, the company did not hold a private operations certificate under CARs Subpart 604. Since C-GJSU is a pressurized turboprop and was carrying passengers, the flight had to be operated under CARs Subpart 703. The flight therefore had to comply with the COM.

However, the pilot mistakenly believed that compliance with the COM was not required for this private flight. As a result, the pilot used the CARs requirements for private flights to determine that 500 pounds of fuel were required to complete the flight and land with a reserve of 300 pounds. In addition, none of the flight documents required by the COM were filled out or submitted to the operations manager before departure.

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91 Calculated based on an average fuel consumption of 600 pounds per hour: a 20-minute flight, 15 minutes to reach the alternate airport (Montréal/Pierre-Elliott-Trudeau International Airport [CYUL], Quebec), plus a 45-minute reserve.

The pilot estimated that there were 580 pounds of fuel on board, and assumed that there was therefore enough fuel to carry out the flight in compliance with the CARs. Consequently, the pilot decided not to refuel C-GJSU before undertaking the flight, to avoid having to refuel a second time afterward (given that another flight with full tanks was scheduled for the next morning). The pilot's decision to follow the requirements of the CARs rather than those of the COM to avoid refuelling the aircraft led to a reduction in the quantity of fuel reserves on board.

2.2.4 Cross-checking of gauges and awareness of fuel status

Given the serious consequences of aircraft fuel exhaustion, it is essential that fuel gauge readings be cross-checked before a flight is undertaken in a minimum-fuel situation. A simple and reliable method of cross-checking involves multiplying the average fuel consumption by the total actual flight time. Given an average fuel consumption by the BE10 of 600 pounds per hour (equivalent to 10 pounds per minute), and given that the total actual flight time between CYYG and CYHU had been 2 hours 48 minutes, it was possible to estimate an approximate fuel consumption of 1680 pounds.

The weight-and-balance form completed for the flight from CYYG indicated that the aircraft had departed with 1860 pounds of fuel on board. The TSB's calculations determined that the actual quantity was approximately 1850 pounds, which supports the number entered on the weight-and-balance form.

With 1860 pounds of fuel on board at the time of departure from CYYG and a fuel consumption of approximately 1680 pounds, there would have been approximately 180 pounds (18 minutes) of fuel remaining on arrival in CYUL. The large difference between the estimated quantity of fuel remaining and the pilot's reading of 580 pounds on the fuel gauges could have led the pilot to question this reading of the gauges.

Since it is unlikely that the pilot would have knowingly undertaken the flight with only 180 pounds of fuel on board, it can be concluded that the pilot relied exclusively on the gauge readings to determine the quantity of fuel on board, without cross-checking the fuel consumption since the last fuelling to validate those gauge readings.

2.3 Fuel on board C-GJSU

2.3.1 Fuel gauge system

To verify the reliability of the fuel quantity indications it provided to the pilot, the gauge system was examined by the TSB. Gauge system tests carried out in situ revealed negligible fuel indicator deviations not exceeding 25 pounds (approximately 2 minutes 30 seconds of flight).

The results of tests performed at the TSB Laboratory established that, in general, the gauges under-represented the quantities of fuel associated with this occurrence,[92] with no abnormal movement of the indicator needle. Of 48 gauge readings taken, 45 under-represented and 3 over-represented the quantity of fuel in the tanks, with a maximum deviation of 8 pounds.[93]

Thus, there was no indication that the aircraft's fuel gauges were not functioning properly at the time of the occurrence flight, and it is unlikely that a deviation of the fuel gauge indicator was a factor in the pilot's decision to take off.

2.3.2 Fuel at the time of departure

According to either method of calculating the fuel for the 4 flights between the last fuelling and CYHU, there was between 170 and 210 pounds of fuel upon arrival at CYHU. However, the reverse calculation to determine the quantity of fuel upon departure from CYHU based on the consumption during the occurrence flight is more precise, since the flight time was less than 24 minutes. Consequently, the quantity of fuel upon departure from CYHU has been established at approximately 260 pounds.

Based on the results of the tests performed on the gauge system by the TSB, it is very likely that C-GJSU's fuel gauges were showing 260 pounds (130 pounds in each nacelle tank) at the time of departure from CYHU.

2.3.3 Fuel gauge readings at the time of departure

Given that there was no defect in the gauge system, and given that C-GJSU had approximately 260 pounds of fuel on board according to various calculations of fuel consumption, it is likely that an erroneous reading of the fuel gauges by the pilot led to the pilot's estimate that there were 580 pounds of fuel on board.

Aviation Flycie Inc. did not record the quantity of fuel in the aircraft logbook before each flight, and existing regulations did not require that this be done. Yet, pilot access to that information constitutes one of the main defences against fuel exhaustion.[94] Without such records, fuel data are not immediately available to pilots. As a result, without these data, pilots may not readily cross-check the accuracy of the gauges. Thus, unless fuel quantity is verified visually, pilots may not notice deviations in the readings. However, a visual check of

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92 Those quantities ranged between ¾ and ⅛ of tank capacity.

93 8 pounds of fuel is equivalent to 48 seconds of flight.

94 Bureau d'Enquêtes et d'Analyses pour la sécurité de l'aviation civile (BEA) de France, *Étude : Pannes d'essence en aviation générale*, available at: http://www.bea.aero/etudes/pannes.d.essence/pannes.d.essence.pdf (last accessed 28 August 2015).

the fuel on board is not reasonably possible for the BE10, hence the importance of tracking fuel quantities before flights.

2.3.3.1 *Pilot's reading of the fuel gauges*

At the time of departure from CYHU, the wing tanks were empty, and each of the nacelle tanks contained approximately 130 pounds of fuel. Although the gauge indicator needles were showing slightly more than ¼ tank of fuel in each nacelle tank (Figure 9), the needles were positioned at the midpoint of the dial because of the non-linear graduation scale of the gauges. Seeing the needle at the midpoint of the dial could have led the pilot to conclude that the tanks were half full.

Figure 9. Illustration of the quantity of fuel before the occurrence flight

Further, although the fuel gauges of the wing tanks are similar to those of the nacelle tanks, the graduation scales of the 2 types of gauges differ. The "F" position on each fuel gauge dial represents 871 pounds in the wing tanks, but 382 pounds in the nacelle tanks. Similarly, the midpoint of the dial represents 310 pounds in the wing tanks, but 130 pounds in the nacelle tanks.

Based on these gauge characteristics, it was hypothesized that the pilot might have established a false equivalence between the visual position of the needle (Figure 10) and the total quantity of fuel in the tanks. However, given that the sum of 2 half-full nacelle tanks would have been about 382 pounds of fuel and the pilot estimated that 580 pounds remained, that hypothesis was ruled out.

Figure 10. False equivalence between the gauge needle position visually and its actual indication of fuel quantity in the nacelle tanks

A second hypothesis examined whether a combination of work habit rules and errors might have led to the pilot's misreading of the fuel gauges.

As a general rule, flights departed with the nacelle tanks completely full and the fuel gauge needles at the "F" position. Since the fuel consumption of both engines is generally similar, the quantity of fuel in the wing tanks can be determined by reading one of the wing tank gauges and multiplying that reading by 2.

By that method, the total quantity of fuel on board can be determined by adding the quantity of fuel in the wing tanks to the total quantity in the nacelle tanks.[95] However, on the day of the accident, the wing tanks were empty and the nacelle tanks were not full, so this method could not be used in the usual manner.

Under this second hypothesis, the pilot might have adapted the usual method while transposing the needle on the scale of the nacelle tank gauges to the scale of the wing tank gauges. Thus, the pilot would not have read the scale above the nacelle tank gauges because of not being accustomed to using them. This association between the usual method of gauge reading and a quantity of fuel would have established a long-term memory schema[96] and resulted in a reading by the pilot that was familiar but incorrect. The recall of familiar information takes place in this way when such indications or contexts are sufficiently similar.[97]

If the pilot transposed the gauge needle of the wing tank at the midpoint of the scale, it would have resulted in a reading of around 300 pounds for each tank, for a total of 600 pounds (Figure 11).

Figure 11. Transposition of the nacelle tank gauge needle to the scale of the wing tank gauge would result in a reading of approximately 300 pounds of fuel.

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95 According to the scale, the total quantity of the 2 nacelle tanks is 764 pounds.

96 Mental representations coded in the memory are schemas that organize events, contexts or experiences in a structured fashion. Drew Westen, *Psychology: Mind, Brain and Culture,* 2nd Edition, John Wiley & Sons Inc., pp. 339–344.

97 P. Lemaire, *Psychologie cognitive,* Éditions De Boeck Supérieur, 1999, Chapitre 3 - MLT Stockage et Récupération de l'information.

Figure 12. Transposition of the nacelle tank gauge needle to the scale of the wing tank gauge would result in a reading of approximately 1100 pounds of fuel.

Moreover, although the weight-and-balance form of the previous flight between CYUL and CYHU showed 1100 pounds of fuel, there were approximately 400 pounds on board (200 pounds in each nacelle tank) based on calculations. By transposing the needle of the nacelle tank gauge at that quantity to the scale of the wing tank gauge, one would arrive at a reading of approximately 550 pounds per tank, or 1100 pounds in total (Figure 12).

The second hypothesis could therefore explain the use of inaccurate quantities of fuel by the pilot at the beginning these 2 flights.

Notwithstanding the reason for the pilot's misinterpretation of the fuel gauges, the pilot misread the fuel gauges and assumed that the aircraft had enough fuel on board to meet the minimum fuel requirements of the CARs for this VFR flight, rather than adding more fuel to meet the greater reserves required by the COM. The result was that the aircraft took off with less than 24 minutes of fuel on board, increasing the risk of fuel exhaustion during a flight that was expected to last from 15 to 20 minutes.

Given that the pilot was the chief pilot, responsible for training new pilots, and was the sole pilot of the company's only aircraft, it is reasonable to expect the pilot to be aware of the quantity of fuel consumed since the last fuelling and to be familiar with the characteristics of the gauge system, since training would have involved explaining them to the other pilots.

2.3.4 Fuel management and situational awareness

To track the quantity of fuel on board, the fuel gauges are generally checked at strategic phases of the flight: before takeoff, while cruising, before deciding to extend a flight, and in any situation that delays landing.

The aircraft checklists used by Aviation Flycie Inc. call for pilots to check the quantity of fuel twice before takeoff and once after reaching cruising altitude. However, if the pilot misinterpreted the quantity of fuel during the initial pre-takeoff check , it is reasonable to assume that the pilot would make the same mistake in subsequent checks, if there were any.

The most critical point in the flight occurred 15 minutes after takeoff, when the pilot, having completed the tests, decided to extend the return flight to practise an instrument landing system (ILS) approach to Runway 24R at CYHU. When the pilot requested clearance from air traffic control (ATC) to do so, the aircraft had enough fuel remaining for 8 minutes 25 seconds of flight, and was 7 minutes 35 seconds[98] from the runway at CYHU.

Extending the return path to position the aircraft at 10 nautical miles (nm) on final approach on the ILS glideslope increased the flight time by approximately 4 minutes 30 seconds. As a result, C-GJSU no longer had enough fuel to reach CYHU, and it ran dry at 7.4 nm on final approach to the runway. The pilot did not monitor the fuel gauges while in flight and decided to extend the flight to carry out a practice instrument approach with insufficient fuel on board to complete the approach.

2.4 Pilot's handling of the emergency

2.4.1 First signs of imminent fuel exhaustion

The warning signs of fuel exhaustion were the changes in the propeller noise and the illumination of the RH FUEL PRESSURE light when C-GJSU was 3.2 nm east of the St-Mathieu-de-Beloeil Airport (CSB3), Quebec,[99] at an altitude of approximately 3000 feet above sea level (asl). It was at this point that the pilot noticed that the nacelle tank gauge needles were showing "E" (Figure 13). The pilot's sudden realization that the gauges were on "E" indicate that the gauges had likely not been monitored during the flight. If pilots do not regularly check the quantity of fuel on board, there is an increased risk of fuel exhaustion.

The procedure to be used in the event of a boost pump failure assumes that the boost pump has failed. However, in this occurrence, the primary boost pump introduced air into the supply line because of the low quantity of fuel in the tank, which caused a drop in fuel pressure and a change in power in the right engine, and led to a momentary dip in the propeller's revolutions per minute (rpm).

Instead of carrying out the procedure for boost pump failure, the pilot switched all of the boost pumps to ON and opened the crossfeed valve. This response suggests that the pilot based those actions not on a failure of the boost pump, but rather on a need to address a potential fuel supply problem due to the low quantity of fuel observed.

Because the crossfeed valve connects the left fuel tanks to the right fuel tanks, doing so can aggravate the emergency and potentially cause fuel exhaustion if there is a fuel leak.[100] If

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98 Approximately 5 minutes 35 seconds of flying time, plus 2 minutes for the circuit toward Runway 24R = 7 minutes 35 seconds.

99 C-GJSU was 11.3 nautical miles east of Montréal/St-Hubert Airport (CYHU), Quebec.

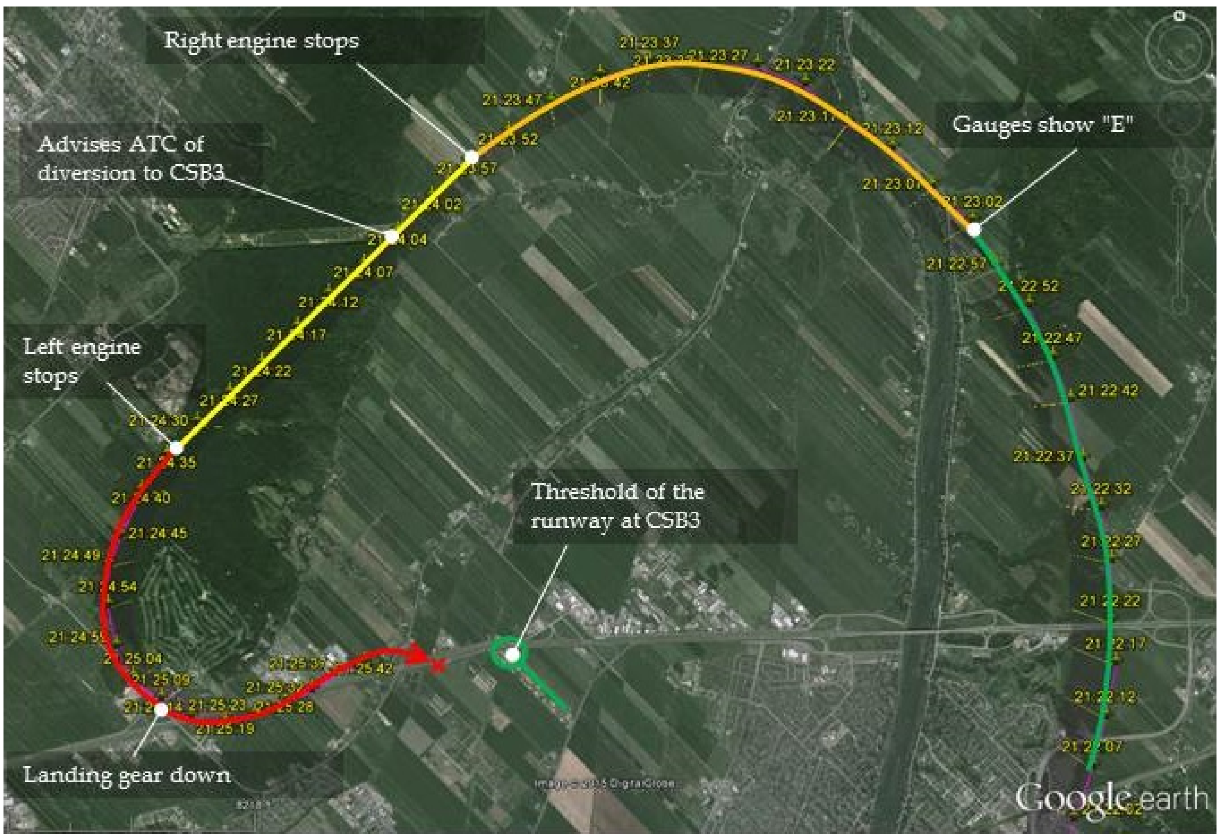
100 Government of Portugal, MINISTÉRIO DAS OBRAS PÚBLICAS, TRANSPORTES E COMUNICAÇÕES, Aviation Accidents Prevention and Investigation Department, Accident Investigation Final Report 22 / ACCID /GPIAA / 2001 (All Engines-out Landing Due to Fuel Exhaustion, Air Transat Airbus A330-243 marks C-GITS Lajes, Azores, Portugal 24 August 2001).

pilots do not rule out a fuel leak before opening the crossfeed valve, they risk losing all of the remaining fuel on board.

2.4.2 First engine stops (right engine)

The right engine stopped due to fuel exhaustion about one minute after the pilot noticed that the gauges were showing "E", when C-GJSU was on the glide path 9.5 nm from Runway 24R, 2600 feet asl, and travelling at around 180 knots (Figure 13). Six seconds after the right engine stopped, the pilot advised ATC of the intention to land at CSB3, without explaining the reason for diverting.

Figure 13. Flight path of C-GJSU until the moment of impact (Source: GoogleEarth, with TSB annotations)



Apart from the fluctuation in propeller sound when the propeller's governor adjusted the pitch, the propeller sound did not change after the engine stopped. Because propeller rpm is not an indication of engine status, the pilot must identify the engine failure by checking the engine gauge readings and the warning lights on the annunciator panel.

Performing the first 3 items of the in-flight engine failure procedure enables the pilot to confirm engine failure, reduce the drag caused by the windmilling propeller, and secure the engine, among other things. The chief pilot had practised this procedure, which is published in the company's standard operating procedures (SOP), during training and during the PPC on the BE10. However, during flight training and during the PPC, the propellers were not feathered, and some items of the checklist, such as shutting down the engine by means of the condition lever, were not carried out.

Nevertheless, with experience as an instructor and in the role of chief pilot responsible for training new co-pilots, the pilot should have known the appropriate procedure and how important it was to carry out all of the items. Yet the pilot did not carry out the engine failure procedure, and the propeller was not feathered. Given that the critical actions of the engine failure procedure could be performed in a matter of a few seconds and that the pilot was not overloaded with tasks, the decision not to carry out the engine failure procedure indicated a lack of understanding of the situation. The pilot did not carry out the approved engine failure procedure when the first engine stopped, and the propeller was not feathered, resulting in significant drag which reduced the aircraft's gliding range after the second engine stopped.

2.4.3 Second engine stops (left engine) and gliding flight

The left engine stopped due to fuel exhaustion 36 seconds after the right engine stopped, when the aircraft was 7.4 nm from Runway 24R at CYHU and 2400 feet asl (Figure 13).

The critical items of the in-flight engine failure procedure include feathering the propeller. However, if the second engine fails, the procedure specifies *not* to feather the propeller, because it will remain feathered as long as the engine is not running. Given that both engines had stopped due to fuel exhaustion and there was no specific procedure for that emergency, a general understanding of the situation would have confirmed that nothing could be done to restart the engines. In such conditions, the complexity of the procedure was considerably reduced, and the priority tasks consisted essentially of feathering the propellers. None of the emergency procedures were carried out, and the propellers were not feathered.

At that point, faced with a total loss of engine power, the pilot initiated a left turn toward CSB3 while gliding.

The glide ratio is essentially the horizontal distance travelled in relation to the change in altitude. Therefore, the higher the glide ratio, the greater the distance that will be travelled. Since the glide ratio is mainly affected by drag, any increase in drag increases the rate of descent, which reduces the flying time and in turn reduces the horizontal distance travelled (i.e., the glide ratio).

Even though the best glide speed is not stated per se in the BE10 flight manual, the pilot could have used the recommended single-engine best rate-of-climb speed. That speed corresponds to the minimum drag speed and is represented by a blue line on C-GJSU's airspeed indicators at 119 knots.[101] The rate of descent and glide speed of C-GJSU while gliding at a speed of 120 knots were calculated to determine the effects on the glide ratio of the drag caused by various configurations (Table 10).

Table 10. Rate of descent and glide ratio when gliding with no flaps

Propellers feathered	Landing gear	Rate of descent (feet/min)	Glide ratio
2	Retracted	976	12:1
1	Retracted	1762	7:1
0	Retracted	2547	5:1
0	Down	3046	4:1

During the left turn toward CSB3, C-GJSU—without feathered propellers and with the landing gear retracted—had a glide ratio of 5:1. Once the turn was completed, C-GJSU was 1.4 nm from the runway and 1290 feet asl (1240 feet above ground level [agl]), which corresponds to a glide ratio of 7:1. Therefore, C-GJSU would have needed to be configured to achieve a glide ratio of at least 7:1 to reach the runway at CSB3. As a result, C-GJSU could not reach CSB3 in the configuration that it was in at the time of the occurrence.

If the engine failure procedure had been carried out when the first engine stopped and if the propeller had been feathered, C-GJSU could have achieved a glide ratio of 7:1 with the landing gear retracted, and then likely would have been able to reach Runway 15 at CSB3. In any event, the pilot lowered the landing gear before completing the turn at 1600 feet asl, thereby reducing the glide ratio to 4:1.

Given the high rate of descent, it is likely that the pilot reduced the speed in an attempt to prolong the glide, to the point where the stall warning horn sounded intermittently beginning at approximately 1000 feet asl.[102] However, the reduction in speed below the minimum drag speed increased the drag and reduced the glide ratio.

When gliding at a constant speed, the point on the ground that appears to remain fixed in the windshield represents the landing point. If the target landing point moves lower, the aircraft will overshoot the target, and the pilot will have enough surplus energy to offset the increased drag caused by lowering the landing gear and the flaps before landing. If the target landing point moves upward, it will not be possible to reach the target in the existing configuration.

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101 The weight of the aircraft was 7800 pounds, so according to the performance chart of the *Pilot Operating Handbook* (POH), the single-engine best rate-of-climb speed (V_{YSE}) was 110 knots, and it could be used to achieve the maximum glide ratio.

102 22 seconds before impact.

Reducing speed when the second engine stopped, from 180 knots to the stall limit, affected the movement of the selected landing point in the windshield. It was only once the aircraft had stabilized at a constant speed that a point on the ground became fixed on the windshield and represented the point on the ground that C-GJSU could reach. As a result, the reduction in speed may have delayed the pilot's decision to make a forced landing in a field (Figure 14).

Figure 14. Flight path toward Runway 15 at St-Mathieu-de-Beloeil Airport (CSB3), Quebec (Source: GoogleEarth, with TSB annotations)

The pilot's decisions and actions that reduced the glide ratio also shortened the amount of time before C-GJSU reached the ground. The high rate of descent gave the pilot less time in which to choose a field, formulate a plan, and prepare the aircraft and the passengers for a forced landing. As a result, the pilot was likely task-saturated and focused all attention on flying the aircraft until realizing, at approximately 450 feet agl, that the aircraft would not be able to reach the runway at CSB3.

Therefore, 12 seconds before impact, the pilot initiated a right turn toward a field bordered by electrical wires. Nine seconds before impact, the stall warning horn began sounding continuously until the right wing struck the ground 40 feet short of the selected field, at an angle of approximately 45°.

Given that the stall warning horn was sounding before C-GJSU struck the ground at a steep angle just short of the electrical wires and the field, the aircraft experienced an aerodynamic stall, and the pilot lost control of the aircraft while attempting to fly over the wires at the perimeter of the field. If a pilot does not maintain control of an aircraft until landing, the force of an impact following an aerodynamic stall is likely to be far greater, increasing the risk of injury or death during a forced landing.

2.4.4 Communications with air traffic control

The fact that the first engine stopped must not have come as a surprise to the pilot, because on becoming aware of the quantity of fuel on board, the pilot was in a position to anticipate that the aircraft's fuel would run dry. In fact, 6 seconds after the right engine stopped, the pilot advised ATC of the intention to land at CSB3, without explaining the change in destination.

2.4.4.1 Declaration of emergency (distress)

Because the aircraft was in a state of emergency that can be qualified as in distress, the decision to land at CSB3 was not a choice/course of action for which clearance from ATC had to be obtained.[103] In such a circumstance, a pilot must take whatever steps are necessary to ensure the safety of the flight. Accordingly, the pilot needed, first and foremost, to carry out the critical items of the engine failure procedure, initiate a turn toward Runway 15 at CSB3, and then clearly and unambiguously declare the state of emergency to ATC using the appropriate distress signal.

The pilot had neither declared an emergency nor notified ATC of the situation. The controller was somewhat puzzled by the change in plan, since C-GJSU was on final approach and 9.5 nm from CYHU, and asked the pilot to confirm that the aircraft was no longer going to land at CYHU. These communications lasted 17 seconds, at the end of which the controller cleared the flight to proceed to CSB3. Meanwhile, C-GJSU remained on its flight path toward CYHU (Figure 15).

Use of the distress signal "MAYDAY MAYDAY MAYDAY", followed by a brief statement about the imminent fuel exhausion and the preferred plan of action, would have reduced the communication time and eliminated any confusion about the pilot's requests. At the same time, it would have enabled ATC to grant priority to C-GJSU and provide the necessary assistance, while limiting communications to those dealing with the situation. Since the aircraft was on radar vectors, the controller would have been able to direct the pilot toward Runway 15 at CSB3 by means of the shortest flight path. In addition, the controller would have been able to inform the appropriate emergency services and coordinate a response with the various agencies involved.

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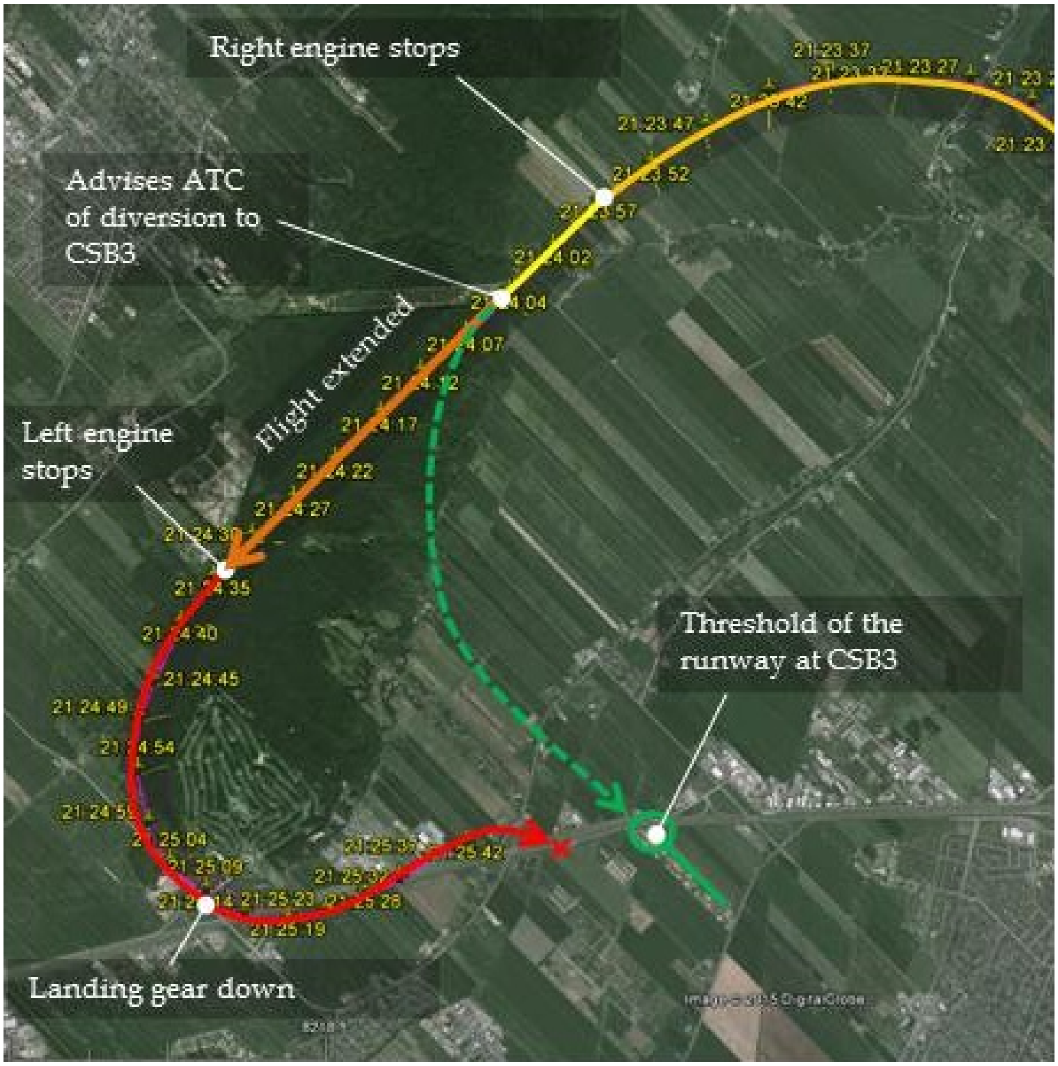
103 "Emergency Communications: […] *Distress*—A condition of being threatened by serious and/or imminent danger and of requiring immediate assistance. The spoken word for distress is MAYDAY, and it is pronounced three times." (Source: *Transport Canada Aeronautical Information Manual* (TC AIM), section COM 5.11.)

Figure 15. Extension of the flight path toward St-Mathieu-de-Beloeil Airport (CSB3), Quebec (Source: GoogleEarth, with TSB annotations)



Unaware of the flight's emergency status, the controller acted in accordance with normal communications procedures found in the *Air Traffic Control Manual of Operations* (ATC MANOPS). As a result, the information that was transmitted and the requests that were made by the controller constituted a source of distraction for the pilot. The last communication from the controller to C-GJSU took place 13 seconds after the second engine stopped, and consisted of informing the pilot of nearby traffic and clearing the pilot to switch to the enroute frequency. If a pilot does not declare an emergency to ATC in a timely manner, the pilot may be deprived of assistance and resources that could help deal with the emergency, increasing the risk of an accident.

2.4.4.2 *Priority given to communications*

In not declaring the aircraft's emergency situation to ATC, the pilot was deprived of assistance that could have lightened the workload in the cockpit.

The pilot continued flying toward CYHU, despite having advised ATC of the intention to divert to CSB3, and without communicating the emergency. The priority given to communications affected the pilot's ability to deal with the situation when the first engine stopped and resulted in the aircraft moving farther away from the intended diversion airport. As a result, delaying the turn to the left toward CSB3 jeopardized the achievement of the pilot's plan to land on the runway.

The pilot's communications with the controller were probably a reaction to the stress of the situation and to the pilot's application of the rules governing ATC communications in normal conditions. Normally, a pilot flying within controlled airspace must inform ATC before deviating from a clearance, in order to obtain a new clearance. Since the pilot's training had taken place under normal flying conditions, the pilot was in the habit during engine failure simulations of contacting ATC before deviating from the clearance received.

Pilots are rarely faced with situations in which prioritizing tasks is crucial to the safety of a flight. However, when the pilot advised of the intention to land at CSB3, the fuel exhaustion of the second engine was imminent, and there was little flying time left before C-GJSU struck the ground.

The pilot had the flight training required by regulation. During training, however, ATC instructions must not be disregarded, nor may an emergency be declared for the purpose of being given priority and assistance. As a result, flight training does not lend itself to practising the type of complex emergency in which tasks have to be prioritized.

When pilots have not had opportunities to practise complex emergency situations that require prioritizing tasks on a simulator, they have a tendency to give priority to ATC communications to the detriment of dealing with an emergency. As a result, if pilots do not receive training in dealing with complex emergencies that require prioritizing tasks, there is a risk that they will not react effectively to emergencies, increasing the risk of an accident.

2.4.5 Overall pilot performance

The situation deteriorated rapidly soon after the pilot realized that there was no more fuel on board. The fuel exhaustion of the right engine subsequently confirmed the aircraft's critical fuel status. The decisions and actions by the pilot all contributed to the elimination of any possibility of reaching the runway:

- giving priority to communications with ATC;
- staying on course for CYHU until the second engine stopped;
- not carrying out the engine failure procedure, which required feathering the propeller, among other tasks;
- lowering the landing gear at 1600 feet asl; and
- using an inappropriate glide speed.

The pilot's decision to lower the landing gear while the aircraft was still at 1600 feet asl further increased the drag, reducing the aircraft's gliding range. As a result, the aircraft was not able to reach the runway at CSB3. Finally, reducing speed in an attempt to prolong the glide to get past the electrical wires at the perimeter of the field resulted in an aerodynamic stall and an impact 30 feet short of the selected field.

The overall handling of the emergency and of the glide up to the point of loss of control of C-GJSU before impact demonstrated performance below the standard expected of a BE10 pilot-in-command, and particularly below that expected of a chief pilot.

2.4.6 Previous pilot performance

The investigation revealed previous substandard performances by the pilot including one instance under the previous employer, who terminated the pilot's training as a BE10 co-pilot. Aviation Flycie Inc. was not aware of these previous non-standard performances, and TC did not take the pilot's work history into consideration in the approval process of the chief pilot appointment.

A pilot may occasionally fail a flight test or PPC. However, recurring failures at regular intervals, together with marginal performance when undergoing a flight test, indicate general performance issues that need to be followed up. If companies do not establish a process to monitor the performance of their pilots during training and testing, there is a risk that those companies will inadvertently assign pilots to carry out flights for which they are not proficient.

Although the pilot had successfully passed the PPC that took place less than 3 months before the accident, the pilot's performance had been marginal. However, performance levels are not monitored or followed up and, in TC's view, a pass—however marginal it may be—is accepted without taking the pilot's work history into consideration. As a result, TC approved the appointment of the chief pilot, and the company assigned the pilot the duties of chief pilot without fully appreciating the significance of the pilot's marginal performance during the PPC.

2.5 Flight supervision by the company

2.5.1 Company managers

Aviation Flycie Inc. was a recently formed company founded in 2012. Given that it was a small operator, its president performed the duties of accountable executive and operations manager. However, the president had no work experience in commercial air carrier operations.

The operations manager hired a captain to hold the position of chief pilot and a co-pilot for the position of person responsible for maintenance (PRM). The chief pilot had limited experience in commercial IFR operations and no experience as pilot-in-command of a BE10. The co-pilot had no experience in commercial IFR operations and none on the BE10. The new pilots' previous work experience and performance were not verified with their previous employers, and the captain's non-certified flying hours were not validated.

In short, the 3 managers had no relevant previous experience for the positions they were going to hold. The chief pilot had only just been promoted as captain on the BE10 after a marginal PPC. The operations manager was unable to fully appreciate the significance of the chief pilot's marginal performance.

2.5.2 Operational control of Aviation Flycie Inc. flights

The main duty of the operations manager is to ensure the safety of flight operations by controlling the operations, verifying the qualifications of crew members, and supervising crew schedules and training, while making sure that the company complies with existing regulations.

On a day-to-day basis, the operations manager authorizes a flight and then delegates operational control of the flight to the pilot, while remaining responsible for ensuring that the flight is carried out in accordance with CARs requirements. Flight authorization consists of reviewing all flight information and preparations to ensure the safety of the passengers and crew.

According to the COM, to ensure a maximum level of safety, the flight must be authorized by the operations manager or the pilot. Generally, a system of checks and cross-checks is established to reduce the risks associated with air operations. However, there is no cross-check if the flight is authorized solely by the pilot of that flight.

Also according to the COM, flight preparations must be carried out by the pilot with the co-pilot's assistance; however, the distribution of tasks is not defined. In fact, the co-pilots prepared the aircraft without taking part in flight planning.

When risks are managed by means of a single layer of defence, such as relying on a single person to ensure flight safety, deviations from regulations or from standard practice can occur, thereby increasing the risk of incident or accident. As a result, if a flight is planned and authorized solely by the pilot, with no cross-check for compliance with existing regulations, there is a risk that deviations will continue undetected, reducing the safety of the flight.

2.5.2.1 Operational irregularities

As Aviation Flycie Inc.'s sole pilot-in-command, the chief pilot carried out all flights after the company commenced operations. A review of the company's records (section 1.18.1.6) revealed that 26 of the 41 commercial flights it had carried out (63%) had been non-compliant with the COM. Irregularities were noted in areas involving training of co-pilots and their assignment to commercial flights, weight-and-balance calculations, and planning and management of fuel on board.

The fact that 63% of the flights carried out were non-compliant indicated deficiencies in flight planning and management, raising questions about the chief pilot's ability to carry out flights in compliance with the regulations.

Those operational irregularities had no obvious consequence on the flights, as they were completed with no reported incidents. However, the instances in which C-GJSU was operated beyond the upper rear limit of the weight-and-balance envelope could have led to aerodynamic instability at low speeds, reducing the safety margins provided by the manufacturer.

In general, the pilot calculated a fuel consumption of between 40 and 100 pounds for taxiing. However, in the cases of flights with irregularities beyond the limits of the weight-and-balance envelope, the pilot had entered 506.3 pounds of fuel for taxiing on the weight-and-balance form. The fact that C-GJSU's centre of gravity was outside the weight-and-balance envelope when calculated using the fuel quantity normally used for taxiing appeared to indicate intentional action on the pilot's part to artificially move the centre of gravity to within the prescribed limits.

A review of the company's operational flight plans showed that over 30% (14) of the flights carried out by the chief pilot did not meet the COM's fuel requirements. Of those 14 flights, 11 did not have the IFR fuel reserves required at landing: 5 of them had less than 45 minutes of fuel on board, 3 had less than 25 minutes of fuel, and 3 lacked sufficient fuel to reach the alternate airport. The fact that 30% of the flights did not meet the COM's fuel requirements indicated an inclination by the chief pilot toward non-compliance with rules. Further, landings with less than 25 minutes of fuel remaining in IFR flight are non-standard and potentially dangerous. Such risky behaviour, repeated several times, indicated that the pilot had likely developed a tolerance to flying with a low quantity of fuel.

These practices by the chief pilot, who was the only individual to fly with all of the co-pilots, increased the risk of transferring these adaptations to the rules established for carrying out assigned tasks.[104] If pilots operate without regular supervision to ensure compliance with regulations and company procedures, coupled with effective training, there is a risk of procedural adaptations that result in reduced safety margins.

The pilot's work history of substandard performance called into question the ability of the pilot to perform the duties of captain on a BE10. However, the large number of potentially serious deviations from flight safety regulations that were committed by the chief pilot during the few months since flight operations had commenced demonstrated an unacceptable performance for a captain and confirmed that the pilot was unfit to fulfill the duties and responsibilities of the chief pilot position.

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[104] Sidney Dekker, *The Field Guide to Understanding Human Error*, Ashgate, 2006.

2.5.3 *Effectiveness of flight operations oversight*

The operations manager was not able to detect the deviations from regulations committed by the chief pilot, despite having demonstrated the required knowledge of the COM during the TC approval process. It can therefore be concluded that the operations manager was unable to perform the duties and responsibilities of the position related to monitoring and supervision of flight operations. As a result, the safety of more than half of the flights was compromised.

It is likely that, due to lack of experience, the operations manager relied completely on the chief pilot to ensure the regulatory compliance of co-pilot training and assignment and of flight performance. Nevertheless, it was the duty of the operations manager to ensure the safety of air operations and, despite delegating those tasks, the operations manager remained responsible for them.

Although TC had held discussions with the operations manager regarding the chief pilot candidate's generally marginal performance, the operations manager was not formally notified of the approved check pilot's (ACP) concerns following the PPC, of the risk assessment that was carried out, nor of the risks identified by TC. Therefore, it is plausible that the operations manager may have relied on TC's approval of the chief pilot as validation of the pilot's abilities. If companies assign inexperienced personnel to key flight operations management positions, there is a risk that deviations in performance or from regulations will not be detected, reducing the safety of flight operations.

2.6 *Certification and regulatory oversight by Transport Canada*

2.6.1 *Operations management personnel appointment process*

Aviation Flycie Inc. submitted its choice of candidates for the positions of operations manager, chief pilot, and PRM to TC to obtain approval for those candidates to perform those roles. The approval of the operations management personnel appointments was the last step in the process for the company to obtain its operator certificate.

2.6.1.1 *Experience*

Since Aviation Flycie Inc. was a company that was just starting out, there had been no previous operations to guide the operations management personnel, and in this instance, the proposed management team was noticeably lacking in experience in air taxi operations.

TC's approval process assesses each candidate individually, without considering the overall experience of the management team as a whole. As a result, apart from the oversight measures established by the inspectors during the risk analysis carried out at the time of certification, this new company was not subject to any restriction related to its overall management experience, since there is no such requirement in CASS 723.07.

2.6.1.2 Qualifications

TC assessed the proposed candidates in accordance with the criteria set out in CASS 723.07. According to those criteria, the operations manager satisfied the standard by having a commercial pilot licence, a multi-engine class rating, and an instrument rating. However, the operations manager was not qualified on the BE10 and, according to the standard, this qualification was not required. The chief pilot satisfied the standard in having the required minimum number of flying hours when submitting an application for the position, having completed training on the BE10, and having passed a PPC. The PRM met the standard by virtue of being a member of the staff of Aviation Flycie Inc.

The approval process does not take into consideration the previous employment history of candidates, and in the case of this company, which was just getting started, the 3 managers had been appointed all at once. Although it can do so, TC did not check the references from previous employers that the candidates had provided, partly due to the potentially subjective nature of the information that would be obtained from those employers.

In the case of the chief pilot candidate, a background check with previous employers would have revealed that, throughout the candidate's career, this individual had struggled as a pilot, as an instructor, and during training on twin-engine aircraft, including the Beech King Air. Had that information been provided, it would likely have raised legitimate concerns regarding the candidate's ability to perform the duties of chief pilot, to act as pilot-in-command on the BE10, and to serve as training pilot on the aircraft.

That said, TC does not take into consideration a pilot's previous difficulties during the approval process for a chief pilot position. In fact, TC has no method or tool to reject an application for an operations management position on the grounds of previous difficulties.

2.6.1.3 Knowledge

The 3 candidates were required to demonstrate, by means of a written exam and an interview, that they possessed the knowledge necessary to perform their duties. TC's policy with respect to this exam and the interview aims to standardize the approval process and to establish the minimum basic knowledge required to perform the responsibilities of the positions.

The operations manager and the PRM each passed the exam and the interview on the first attempt. The chief pilot passed the exam, but failed the interview on the first attempt due to poor knowledge of the COM and the CARs. On the second attempt, 4 days later, the chief pilot satisfied the knowledge requirements.

Given that the approval process imposes neither a time limit on retaking the interview nor a limit on the number of attempts that can be made in cases of failure, a candidate can continue trying until succeeding.

2.6.1.4 Pilot proficiency check

Given the requirement to be qualified to perform the duties of pilot-in-command on the BE10, the chief pilot candidate had to undergo a PPC. The pilot's performance during the PPC was marginal, with 4 exercises receiving a score of "2". To pass, the maximum permitted number of exercises receiving a "2" is 4.

Although the pilot succeeded in passing the PPC, the resulting score raised concerns, given the duties and responsibilities that the candidate would have as chief pilot. A better performance than one bordering on failure should be expected of a chief pilot who will be responsible for training the company's pilots and administering the co-pilots' competency checks. Yet the criteria for passing a PPC are the same for a chief pilot candidate as for any other pilot.

2.6.1.4.1 Administration of the pilot proficiency check

The TC ACP found it challenging to administer the PPC due to the limited space in the cockpit and the difficulties that the pilot had in carrying out the required exercises. The ACP was task-saturated, frequently taking notes under conditions and in an environment that were not conducive to observing the pilot and the flight data. However, the ACP can require the candidate to repeat an exercise if conditions prevented its proper assessment. Moreover, the ACP is not constrained by any prescribed time limits in carrying out the PPC.

During the exercise on a single-pilot approach, the candidate received assistance from the co-pilot, who warned of a potential deviation in altitude while the ACP was distracted by notetaking. Since the ACP was not able to personally observe the altitude below the minimum descent altitude (MDA) and the pilot responded immediately to the warning, the ACP gave a score of "2" for this exercise and did not require the pilot to repeat the approach, nor was there a requirement to do so.

The candidate's lack of experience, failure of the first interview, and future responsibilities as chief pilot could have led the TC ACP to administer the PPC according to a stricter interpretation of the flight test guides governing the administration of PPCs.[105] However, the guides do not specify any special criterion for a chief pilot, and 5 scores of "2" are required for the PPC to be deemed a failure. A PPC with some scores of "2" may indicate weaknesses that could call into question a pilot's ability to act as captain. If the PPC requirements for a chief pilot are not more stringent than those for other pilots, there is a risk that the chief pilot will be unable to perform the duties required to ensure the safety of company training and operations.

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105 Transport Canada, TP 14727, *Pilot Proficiency Check and Aircraft Type Rating Flight Test Guide*, 2007, and Transport Canada, TP 6533, *Approved Check Pilot Manual*, 9th edition, 2007.

Given that the candidate was to be employed as chief pilot, the ACP, who was concerned about the pilot's overall performance, was faced with a professional dilemma. Despite the candidate's marginal performance, the ACP had to give the pilot a passing mark on the PPC, based on the ACP's interpretation of the flight test guides governing the administration of PPCs.

Furthermore, there is no limit on the number of times a pilot may repeat a PPC. A pilot who fails one can take more training and then do another, any number of times.

The day after the PPC, the TC ACP sent a letter of concern to the inspectors responsible for approving the appointments and for issuing the operator certificate, due to the marginal performance of the chief pilot candidate. The ACP identified flight safety risks and suggested, among other things, that TC should carry out a risk assessment before issuing an operator certificate to Aviation Flycie Inc.

2.6.1.4.2 Suspension or revocation of the pilot proficiency check

According to Staff Instruction No. SUR-014, the Minister has the power to suspend or to revoke a Canadian aviation document (CAD) such as a PPC in cases of immediate threat to aviation safety[106] if there is reason to believe that the pilot is incompetent,[107] or as a matter of public interest.[108]

The deficiencies in knowledge and ability that the chief pilot candidate exhibited during the approval process were identified by TC as a risk to air safety. However, according to the TC inspectors' interpretation of Staff Instruction No. SUR-014, the pilot's weaknesses did not meet the criteria for suspending or revoking the PPC, mainly because the company had not yet commenced flight operations. Thus, in the absence of a history of repeated non-compliances, the inspectors lacked sufficient proof to support a decision based on immediate threat to aviation safety, on the pilot's incompetence, or on public interest, especially in a

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106 "An immediate threat to aviation safety is a threat to the safety of an aircraft that currently exists or is about to exist, and creates a reasonable expectation that unless immediate action is taken to neutralize the threat, death, injury or significant damage to property is imminently likely." [Transport Canada, Staff Instruction No. SUR-014, *Suspension or Cancellation of Canadian Aviation Documents for Safety Reasons,* (July 2011), paragraph 4.1 1)]

107 "Incompetence is the inability to perform activities that are authorized in a CAD [Canadian aviation document] in compliance with the regulations and standards applicable to that type of activity." [Transport Canada, Staff Instruction No. SUR-014, *Suspension or Cancellation of Canadian Aviation Documents for Safety Reasons,* (July 2011), paragraph 5.4 3)]

108 "The public interest as asserted by the Minister is a societal interest that relates to the protection and safety of the public and the users of the system as part of its policy regarding the development, regulation and supervision of all matters connected with aeronautics, and the maintenance of an acceptable level of safety." [Transport Canada, Staff Instruction No. SUR-014, *Suspension or Cancellation of Canadian Aviation Documents for Safety Reasons,* (July 2011), paragraph 5.6.1 1)]

context where they bore the burden of proving, based on the balance of probabilities, that such a step was warranted.

2.6.2 Approval of operations management personnel appointments

In short, TC's process for approving operations management personnel appointed by companies is based on the principle of objective standards. If the criteria of the standard are met, the Minister is required to approve the appointments individually.

The pilot's marginal performance both in the interview and during the PPC raised serious concerns at TC regarding the pilot's ability to perform the duties and responsibilities of a chief pilot. However, the CASS contains no criterion linked to potential levels of performance or risk that would constitute grounds for withholding an approval, and the CARs do not specify the conditions under which such approval could be withheld. According to Staff Instruction No. SUR-015, a decision not to approve a company's management personnel must be based on required abilities as set out in the CASS. Thus, according to the TC inspectors' interpretation of this Staff Instruction, the inspector was not in a position to refuse the chief pilot's appointment on the grounds of weak performance, since the candidate satisfied the criteria set out in the standard.

Based on TC's existing policies and process, the TC inspectors determined that the minimum conditions for the approval had been satisfied and that they were therefore required to approve the chief pilot's appointment despite the concerns raised by the ACP. If the approval process for appointment of operations management personnel by companies is reduced to a compliance checklist based on the minimum standards in the CASS and on PPCs that may be repeated an unlimited number of times, there is a risk that candidates who are unfit to perform the duties and responsibilities of their positions will be appointed.

In this instance, at the time the application was submitted, the chief pilot candidate had logged 259 hours as pilot-in-command within the preceding 3 years. However, when the appointment was approved by TC 4 months later, the chief pilot no longer had the 250 hours within the preceding 3 years that are required by the CASS. Therefore, the chief pilot did not meet the requirements of the CARs at the time of appointment

In hindsight it is easy to reach conclusions that correspond to the irregularities found during the investigation. However, in this instance, the numerous weaknesses shown by the chief pilot candidate at the time of appointment, together with the combined lack of experience of the company's management personnel, constituted reasonable grounds for TC to conclude that flight safety at Aviation Flycie Inc. was at risk.

However, TC's approval process provides no criteria for assessing an operations management team as a whole, which in this instance was generally inexperienced and comprised individuals with limited knowledge of air taxi operations. In these circumstances, even if TC personnel were aware of the precarious situation of this new company, they lacked the tools required to refuse the approvals. If TC does not take into consideration the combined knowledge and experience of a new operator's management team, there is a risk that the operator will lack the skills necessary to ensure the safety of flight operations.

2.6.2.1 Risk assessment of the chief pilot's abilities

The ACP's report[109] concluded that the chief pilot's weak technical knowledge and marginal flying abilities compromised the quality of training that would be provided, and adversely affected the chief pilot's ability to act as pilot-in-command in single-crew flight or when paired with an inexperienced co-pilot. The TC ACP also recommended that a risk assessment be carried out before approval of the chief pilot's appointment.

Since the PPC had been passed, the TC inspectors could not suspend or revoke the PPC, nor could they refuse to approve the chief pilot's appointment on grounds of generally marginal performance. Thus, TC's risk assessment focused only on the risks associated with the chief pilot's duties and responsibilities, and as a result, it could not take into consideration the concerns raised regarding the chief pilot's weaknesses as pilot-in-command.

The risk assessment did not consider the impact that the operations manager's inexperience would have on supervision of the chief pilot, in light of the latter's weaknesses. However, the weaknesses observed in the chief pilot candidate, combined with inexperienced management, were enough to enable TC to determine that the supervision of flights and flight safety at Aviation Flycie Inc. were at risk.

In addition, the training provided by the chief pilot could have had a direct influence on the co-pilots' abilities to perform their flight duties. Since the chief pilot would be administering the competency checks of the new co-pilots, there would be no cross-checking of the quality of training provided, as the co-pilots would be tested by the chief pilot who had trained them.

Following the risk assessment, TC set up a schedule to inspect the company every 2 months and recommended open communication with the operations manager. Although the operations manager was aware of the chief pilot's weak performance during the TC interviews and PPC, no formal document spelling out the concerns and risks that were raised by the TC ACP during the approval process was sent to Aviation Flycie Inc.

The risk assessment estimated the level of risk as low to medium, with negligible consequences. However, even if the other risks of a more subjective nature had been assessed and the result had been a higher level of risk, the inspector responsible for approving the personnel appointments was required to approve the chief pilot's candidacy, because all of the criteria set out in the CASS were met.

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109 Letter from the Transport Canada inspector who participated in the chief pilot's interviews and administered the pilot proficiency check.

2.6.3 *Issuance of an operator certificate to Aviation Flycie Inc.*

Subpart 703 of the CARs requires that the Minister issue an air operator certificate if the applicant possesses, in part, management personnel approved by the Minister in accordance with CARs standards.[110] Since its operations management personnel had been appointed, Aviation Flycie Inc. satisfied all of the CARs criteria; therefore, the TC inspector was required to issue the operator certificate on the Minister's behalf, despite the concerns raised and the risk assessment.

As a result, the certification process used by TC enabled Aviation Flycie Inc. to employ an operations manager who had never worked for an air carrier, a PRM who had no experience in maintenance or in air taxi flight operations, and a chief pilot who had just been promoted to captain on the BE10 after performing marginally at the time of the appointment.

2.6.4 *Transport Canada's regulatory oversight of Aviation Flycie Inc. operations*

Given that the risk assessment at the time of issuance of the operator certificate estimated the level of risk as low to medium, with negligible consequences, TC decided, in part, that a planned process inspection (PI) of the company at two-month intervals would be sufficient to mitigate the risks that were identified. The first PI was scheduled for 18 June 2013, but the accident occurred on 10 June 2013.

2.6.4.1 *Planned process inspection after the accident*

Eight days after the accident, TC carried out the planned PI as scheduled following the risk assessment.[111] In planning the inspection, TC decided not to take into consideration the circumstances of the accident. Consequently, the scope of the planned PI was not changed, and was focused on the following processes:

1. the training program;
2. operational flight plans; and
3. flight times and flight duty times.

The accident occurred after only 41 commercial flights had been carried out since Aviation Flycie Inc. had begun its flight operations, and TC was aware that the chief pilot had been flying C-GJSU when it ran out of fuel.

Given the weaknesses of, and the concerns surrounding, the chief pilot's performance during the appointment approval process and the inexperience of the operations management team, TC could reasonably have been expected to proceed with a more in-depth inspection of Aviation Flycie Inc.'s flight operations as part of this PI. However, in light of the other post-

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110 *Canadian Aviation Regulations* (CARs) 703.07(2)*b*).

111 Risk assessment No. GR13-010 carried out due to the weaknesses shown by the chief pilot.

accident activities carried out by TC,[112] it was decided that the scope of the PI would be limited to the processes that had already been identified. If PIs carried out by TC do not examine factors related to a recent occurrence, there is a risk that those hazardous conditions will go undetected and will persist.

The goal of the PI was to determine whether the targeted processes were working and to ensure that regulatory requirements were met. The review of the training process did not identify that a new co-pilot was carrying out commercial flights with passengers. Nor did it identify that the co-pilot was doing so without having completed the ground and flight training required by the COM and while the company did not hold Operations Specification 011, which would have permitted those flights to be conducted with just one qualified pilot.

The review of operational flight plans performed during the PI did not lead to any findings. Yet examination of these flight plans showed that some of the flights could not have been carried out in compliance with the COM. For example, the total quantity of fuel required for one of the flights exceeded the total capacity of C-GJSU's tanks. Neither the total quantity of fuel required nor the total quantity of fuel on board C-GJSU were recorded on the operational flight plan, and the regulations did not require them to be.

The record in which the company entered flight duty times and rest periods was not the form prescribed by the COM, although all of the fields had been completed. However, it had been completed in such a way that the record always showed the chief pilot as being off duty when not flying. As a result, it could not be determined whether the rest periods were complied with when the chief pilot was doing office work and providing ground training.

Thus, the investigation established that several irregularities in operational and regulatory compliance existed in the records related to the 3 company processes targeted by the TC PI, yet those irregularities were not identified during the PI. If PIs carried out by TC on newly certificated operators do not closely examine the outcomes of company processes, there is a risk that hazardous conditions will not be identified and will persist.

2.6.4.2 *Safety management and oversight*

The TSB Watchlist 2014 highlights one issue that specifically concerns safety management and oversight. The solutions proposed by the TSB in this regard could reduce the likelihood that conditions associated with repeated non-compliances would continue, and would thereby reduce the probability of such an accident recurring.

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112 Follow-up on the Civil Aviation Daily Occurrence Reports (CADORS) and enforcement investigation.

This occurrence demonstrated that the company was unable to effectively manage its safety risks. Under such circumstances, TC must not only intervene, but it must do so in a manner that succeeds in changing unsafe operating practices.

2.6.4.3 Revocation of a chief pilot appointment

Inadequate supervision and training of the company's pilots were identified by TC's risk assessment as a potential hazard. The information collected showed that, on 3 occasions, the chief pilot demonstrated poor knowledge of the established standards governing pilot training. On one occasion, the chief pilot administered a pilot competency check (PCC) to a co-pilot with passengers on board, who included the operations manager. One month after the accident, the chief pilot provided training on a type of aircraft without the necessary qualifications for that aircraft, and later recommended a pilot who had not taken the required training for a PPC with a TC ACP. In light of the foregoing, it would appear that the risks that were identified during the appointment approval process materialized.

However, a ministerial approval can be revoked only if one of the initial standards is no longer met.[113] Given the restrictive nature of Staff Instruction No. SUR-015, the suspension or revocation of an approval of an appointment to an operations management position does not depend on the candidate's ability to perform the duties and responsibilities of the position. If the inability of appointed individuals to perform their duties and responsibilities does not constitute grounds for suspending or revoking the ministerial approval of such appointments, there is a risk that operations management personnel who are not competent will remain in their positions, increasing the risk to flight safety.

It is reasonable to conclude that TC's approval process, which is intended to convince the Minister of Transport that the operations management personnel of Aviation Flycie Inc. were able to perform their duties and responsibilities, was not effective. Moreover, once the appointments were approved, the application of the restrictive criteria of Staff Instruction No. SUR-015 prevented TC from suspending or revoking the approvals on the grounds of inability to perform duties and responsibilities.

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[113] Transport Canada, Staff Instruction No. SUR-015, *Refusal or Revocation of Non-Canadian Aviation Document Ministerial Approvals*, (July 2011).

3.0 Findings

3.1 Findings as to causes and contributing factors

1. The pilot relied exclusively on the gauge readings to determine the quantity of fuel on board, without cross-checking the fuel consumption since the last fuelling to validate those gauge readings.

2. The pilot misread the fuel gauges and assumed that the aircraft had enough fuel on board to meet the minimum fuel requirements of the *Canadian Aviation Regulations* for this visual flight rules flight, rather than adding more fuel to meet the greater reserves required by the company operations manual.

3. The pilot did not monitor the fuel gauges while in flight and decided to extend the flight to carry out a practice instrument approach with insufficient fuel to complete the approach.

4. The right engine stopped due to fuel exhaustion.

5. The pilot did not carry out the approved engine failure procedure when the first engine stopped, and the propeller was not feathered, resulting in significant drag which reduced the aircraft's gliding range after the second engine stopped.

6. The pilot continued flying toward Montréal/St-Hubert Airport (CYHU), Quebec, despite having advised air traffic control of the intention to divert to the St-Mathieu-de-Beloeil Airport (CSB3), Quebec, and without communicating the emergency. The priority given to communications resulted in the aircraft moving farther away from the intended diversion airport.

7. The left engine stopped due to fuel exhaustion 36 seconds after the right engine stopped, when the aircraft was 7.4 nautical miles from Runway 24R at Montréal/St-Hubert Airport (CYHU), Quebec, and 2400 feet above sea level.

8. The pilot's decision to lower the landing gear while the aircraft was still at 1600 feet above sea level further increased the drag, reducing the aircraft's gliding range. As a result, the aircraft was not able to reach the runway at St-Mathieu-de-Beloeil Airport (CSB3), Quebec.

9. The operations manager was unable to perform the duties and responsibilities of the position related to monitoring and supervision of flight operations. As a result, the safety of more than half of the flights was compromised.

3.2 *Findings as to risk*

1. If the total fuel quantity required for a flight is not calculated and clearly displayed on the operational flight plan, there is an increased risk that aircraft will depart without the fuel reserves required by the *Canadian Aviation Regulations*.

2. If flights are planned and carried out without the fuel reserves required by the *Canadian Aviation Regulations*, there is an increased risk of fuel exhaustion resulting from unanticipated situations that extend the duration of the flight.

3. If pilots elect to extend flight without first determining whether sufficient fuel reserves are available to do so, there is an increased risk of fuel exhaustion.

4. If pilots do not regularly check the quantity of fuel on board, there is an increased risk of fuel exhaustion.

5. If pilots do not rule out a fuel leak before opening the crossfeed valve, they risk losing all of the remaining fuel on board.

6. If a pilot does not maintain control of an aircraft until landing, the force of an impact following an aerodynamic stall is likely to be far greater, increasing the risk of injury or death during a forced landing.

7. If a pilot does not declare an emergency to air traffic control in a timely manner, the pilot may be deprived of assistance and resources that could help deal with the emergency, increasing the risk of an accident.

8. If pilots do not receive training in dealing with complex emergencies that require prioritizing tasks, there is a risk that they will not react effectively to emergencies, increasing the risk of an accident.

9. If companies do not establish a process to monitor the performance of their pilots during training and testing, there is a risk that those companies will inadvertently assign pilots to carry out flights for which they are not proficient.

10. If a flight is planned and authorized solely by the pilot, with no cross-check for compliance with existing regulations, there is a risk that deviations will continue undetected, reducing the safety of the flight.

11. If pilots operate without regular supervision to ensure compliance with regulations and company procedures, coupled with effective training, there is a risk of procedural adaptations that result in reduced safety margins.

12. If companies assign inexperienced personnel to key flight operations management positions, there is a risk that deviations in performance or from regulations will not be detected, reducing the safety of flight operations.

13. If the pilot proficiency check requirements for a chief pilot are not more stringent than those for other pilots, there is a risk that the chief pilot will be unable to perform the duties required to ensure the safety of company training and operations.

14. If the approval process for appointment of operations management personnel by companies is reduced to a compliance checklist based on the minimum standards in the *Commercial Air Service Standards* and on pilot proficiency checks that may be repeated an unlimited number of times, there is a risk that candidates who are unfit to perform the duties and responsibilities of their positions will be appointed.

15. If Transport Canada does not take into consideration the combined knowledge and experience of a new operator's management team, there is a risk that the operator will lack the skills necessary to ensure the safety of flight operations.

16. If process inspections carried out by Transport Canada do not examine factors related to a recent occurrence, there is a risk that those hazardous conditions will go undetected and will persist.

17. If process inspections carried by TC on newly certificated operators do not closely examine the outcomes of company processes, there is a risk that hazardous conditions will not be identified and will persist.

18. If the inability of appointed individuals to perform their duties and responsibilities does not constitute grounds for suspending or revoking the ministerial approval of such appointments, there is a risk that operations management personnel who are not competent will remain in their positions, increasing the risk to flight safety.

3.3 Other findings

1. The chief pilot did not meet the requirements of the *Canadian Aviation Regulations* at the time of appointment.

2. There was no indication that the aircraft's fuel gauges were not functioning properly at the time of the occurrence flight, and it is unlikely that a deviation of the fuel gauge indicator was a factor in the pilot's decision to take off.

3. C-GJSU had approximately 260 pounds of fuel on board when it took off from Montréal/St-Hubert Airport (CYHU), Quebec, and did not experience a fuel leak during the occurrence flight.

This report concludes the Transportation Safety Board's investigation into this occurrence. The Board authorized the release of this report on 08 June 2016. It was officially released on 17 August 2016.

Visit the Transportation Safety Board's website (www.tsb.gc.ca) for information about the TSB and its products and services. You will also find the Watchlist, which identifies the transportation safety *issues that pose the greatest risk to Canadians. In each case, the TSB has found that actions taken to date are inadequate, and that industry and regulators need to take additional concrete measures to eliminate the risks.*

Appendices

Appendix A – Fuel requirements stipulated in the company operations manual

No one shall operate an aircraft if the following fuel requirements listed below are not met. Whether the flight is undertaken as an IFR or VFR flight, the requirements below must be used as standard requirements for all flights.

Each aircraft must have enough fuel to:

Fly to the destination; and
Fly the approach at the destination; and
Fly the missed approach at the destination; and
Fly to the alternate; and
Land to the alternate; and
Fly for a period of 45 minutes.

Also a sufficient amount of fuel must be carried by the aircraft for:

Taxiing and foreseeable delays prior to take-off; and
Weather conditions; and
Foreseeable air traffic routing and delays; and
Landing at a suitable aerodrome in the event of a failure of any engine at the most critical point during the flight; and
Any other events that could delay the aircraft's landing.

In addition to the above requirements, no IFR flight will be authorized unless the aircraft carries sufficient fuel to:

Descend at any point along the route to the single-engine service ceiling or 10,000 feet, whichever is lower; and
To cruise at the above altitude to a suitable aerodrome; and
To fly an approach and missed approach; and
To hold for 30 minutes at 1,500 feet the aerodrome elevation (mentioned above).

Source: Air Flycie Inc., *Company Operations Manual*

Appendix B – Risk index matrix (TC SGDI-6001872)

(Abridged version)

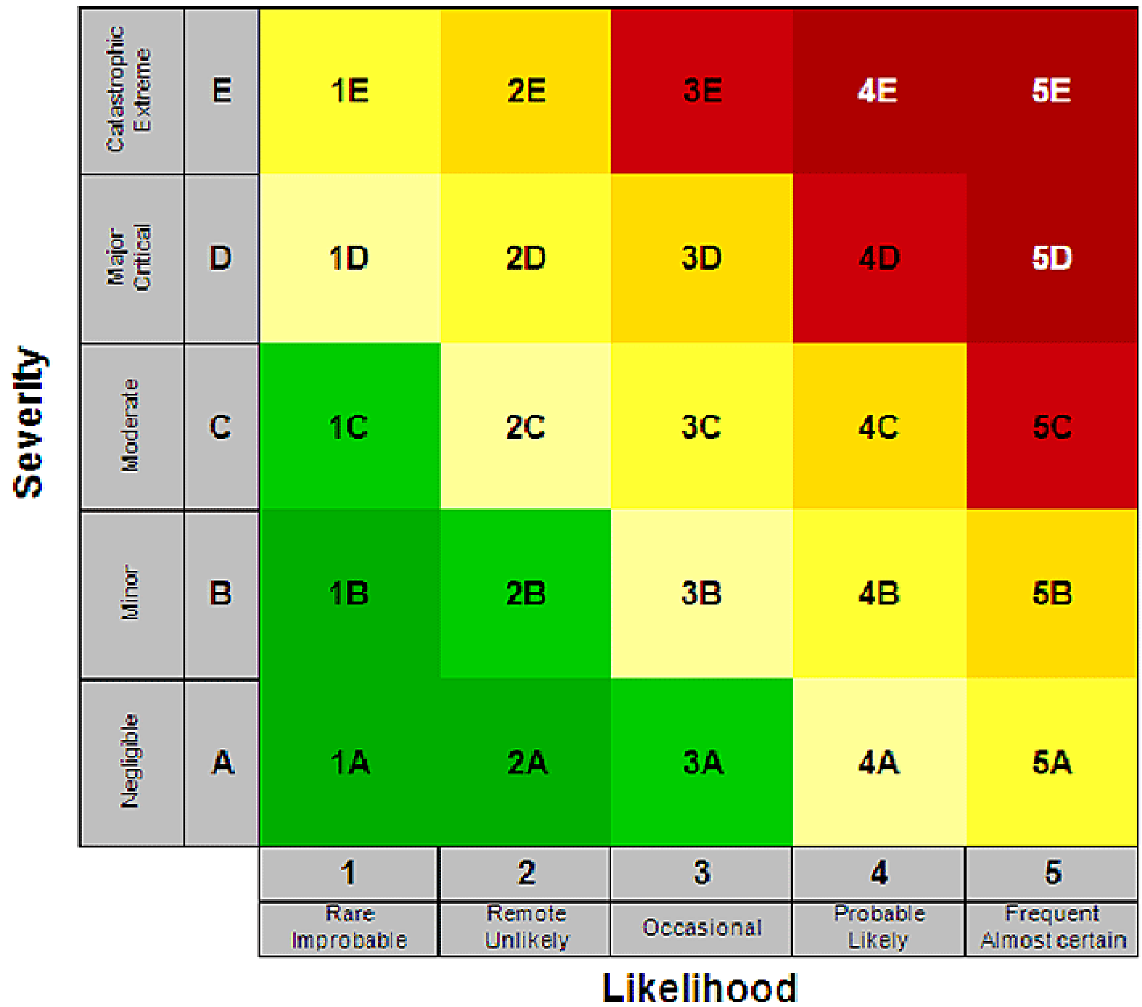
Risk measurement formula
When conducting a Risk Analysis, the Risk Level is based on an evaluation of the following two factors: **Likelihood** that a risk scenario will occur, and **Severity** of the events. The Risk Level is a subset of a two-digit Risk Indicator (number and letter) resulting from the intersection of LIKELIHOOD and SEVERITY on the Risk Matrix as identified in Figure 1 below.

Likelihood (L)	
What is the Likelihood of that sequence of events/situation/activities happening during the exposure interval?	
4 – Probable - Likely	• Will occur several times during the exposure interval
	• Statistically $10^{-3} – 10^{-5}$
	• Event is expected to occur in majority of circumstances

Severity (S)	
The sequence of events has happened. How serious is the severity of the consequences?	
A **Negligible**	• Little to no impact on TCCA program or system objectives • Less than minor injury and/or less than minor system damage ***Personnel:*** No injuries. ***Operations:*** Minor operational delay with no immediate costs. ***Equipment:*** No damage or minor technical delay with no immediate costs. ***Environment:*** Minor contained release that does not significantly threaten the quality of life of humans and/or the habitat. ***Media attention:*** No media attention. ***Public confidence:*** No loss of public confidence.

Figure 1 Risk Matrix

Risk Level = Intersection of Likelihood and Severity



Risk Indicator	***Risk Level***	***Suggested decision***
1D, 2C, 3B, 4A	Low-Medium	**Proceed** after consideration of the risk items. Management effort worthwhile.

Source: Transport Canada

Appendix C – Glossary

ACP	approved check pilot
AFM	aircraft flight manual
agl	above ground level
asl	above sea level
ATC	air traffic control
ATC MANOPS	*Air Traffic Control Manual of Operations*
AWOS	automated weather observation system
BE10	Beechcraft King Air 100
BEA	Bureau d'Enquêtes et d'Analyses pour la sécurité de l'aviation civile (France)
CAD	Canadian aviation document
CARs	*Canadian Aviation Regulations*
CASS	*Commercial Air Service Standards*
CHKL	checklist for normal situations
COM	company operations manual
CSB3	St-Mathieu-de-Beloeil Airport, Quebec
CVR	cockpit voice recorder
CYFC	Fredericton Airport, New Brunswick
CYHU	Montréal/St-Hubert Airport, Quebec
CYRI	Rivière-du-Loup Airport, Quebec
CYUL	Montréal/Pierre-Elliott-Trudeau International Airport, Quebec
CYYG	Charlottetown Airport, Prince Edward Island
CYZV	Sept-Îles Airport, Quebec
ECHKL	checklist for abnormal and emergency situations
ELT	emergency locator transmitter
FAA	Federal Aviation Administration (United States)

GAS GEN	gas generator
GPS	global positioning system
IFR	instrument flight rules
ILS	instrument landing system
M	magnetic (degrees)
MDA	minimum descent altitude
nm	nautical mile
PCC	pilot competency check
PI	process inspection
PPC	pilot proficiency check
PRM	person responsible for maintenance
RNAV	area navigation
rpm	revolutions per minute
SOP	standard operating procedures
TC	Transport Canada
TC AIM	*Transport Canada Aeronautical Information Manual*
TSB	Transportation Safety Board
VFR	visual flight rules