Transportation Safety Board of Canada

Bureau de la sécurité des transports du Canada

AVIATION INVESTIGATION REPORT
A06Q0180

LOSS OF ELECTRICAL POWER

PROPAIR INC.
BEECHCRAFT KING AIR 100 C-GJLP
MONTRÉAL/ST-HUBERT AIRPORT, QUEBEC
18 OCTOBER 2006

Canada

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

Aviation Investigation Report

Loss of Electrical Power

Propair Inc.
Beechcraft King Air 100 C-GJLP
Montréal/St-Hubert Airport, Quebec
18 October 2006

Report Number A06Q0180

Summary

The Beechcraft King Air 100, registration C-GJLP, serial number B 148, operated by Propair Inc. as Flight PRO101, with two pilots and four passengers on board, took off at 0918 eastern daylight time from the Montréal/Pierre Elliott Trudeau International Airport, Quebec, on an instrument flight rules (IFR) flight inbound to Montréal/St-Hubert Airport, Quebec. Shortly after take-off, the generation of electrical power ceased followed by a complete loss of radio navigation equipment, some flight instruments, most engine instrument panel indicators, and a radio communication failure. The crew left the assigned altitude to descend to the minimum sector altitude. A break through the clouds allowed the aircraft to descend below the cloud cover. The crew continued the flight under visual flight rules (VFR), and the aircraft landed without further incident at the Montréal/St-Hubert Airport. There were no injuries or damage to the aircraft.

Ce rapport est également disponible en français.

Other Factual Information

The flight crew was certified and qualified for the flight in accordance with existing regulations. The pilot-in-command had approximately 5500 flying hours, including 300 hours as pilot-in-command on the King Air 100. The copilot had approximately 2200 flying hours, including 200 hours as copilot on the King Air 100.

The pilot-in-command had completed cockpit resource management (CRM) training in March 2005. The copilot, newly hired, had not yet completed this training. According to the *Canadian Aviation Regulations* (CARs), this training is not mandatory for companies operating under Part VII, Subpart 3 of the CARs. However, the operator took the initiative to provide the training every two years to educate its crews on CRM concepts in order to enhance teamwork.

Before departure, the crew completed the flight planning. The pilot-in-command obtained a weather briefing, which was faxed to him. He filed an instrument flight rules (IFR) flight plan from the Montréal/Pierre Elliott Trudeau International Airport, Quebec, to the Montréal/St-Hubert Airport, Quebec. The flight plan indicated a fuel endurance of approximately 5.5 hours. After St-Hubert, the aircraft was to fly to Québec, Quebec, Wabush, Quebec, and Schefferville, Quebec. The weather conditions were instrument meteorological conditions until Québec, but improving for destinations further north. According to the terminal aerodrome forecast (TAF), at the estimated time of arrival at St-Hubert, the crew could expect a broken ceiling at 700 feet, overcast at 1200 feet with a visibility of 5 miles in light drizzle and fog. Temporarily, between 0900[1] and 1100, the broken clouds could become scattered and visibility could be 6 miles in fog.

Engine start-up was normal. While taxiing to Runway 24L for departure, the crew completed the pre-take-off checks and initiated the line-up checks. Since it was number four in the take-off sequence, the crew postponed two items from the line-up checklist, namely activation of the landing lights and engine auto-ignition until the aircraft was on the runway and ready for take-off.

In position on the runway for take-off, the copilot turned on the landing lights and the pilot-in-command completed the checklist by placing what he thought were the auto-ignition switches to the ON position. In fact, he mistakenly switched the ignition and engine start switches to the ignition and engine start position. At that moment, the master caution light illuminated momentarily without any other abnormal indications on the annunciator panel.

The aircraft took off at 0918. The crew was cleared for a standard instrument departure (SID) JADEE SIX Runway 24L. This departure procedure involves climbing to 3000 feet on a heading of 238° before guidance from air traffic control (ATC) and the switch from tower frequency over to terminal frequency. A special aviation weather report issued for Montréal at 0921, three minutes after take-off, indicated scattered clouds at 600 feet, a broken ceiling at 1000 feet, overcast at 2800 feet, with visibility of 3 miles in the drizzle.

---

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

After take-off, the landing gear did not retract normally when the lever was placed in the up position. Although the crew heard the landing gear retraction motor, the gear in-transit light, indicating that the gear did not retract properly, remained on. The crew initiated the post-take-off checklist, and the pilot-in-command recycled the landing gear. At this point, the pilot-in-command realized that the white warning lights of the auto-ignition had remained on. The pilot-in-command operated the auto-ignition switches, but the lights did not go out. The checklist that applies to this anomaly was not completed because the crew was busy finishing the "Abnormal gear indication – All gear OFF/Transition ON" checklist.

At the same time, a loss of radio navigation instruments occurred. Except for the artificial horizon located on the copilot's side, the only functional instruments were pitot static instruments, such as the altimeters, airspeed indicators, vertical speed indicators in addition to the compass and the turn coordinator.

While the crew of Flight PRO101 was dealing with the loss of instruments, the controller made three unsuccessful attempts to communicate with Flight PRO101. At 0925, the controller informed Flight PRO101 that he could see their secondary target on the radar screen, but that their radio transmissions were weak. The heading of 050° was assigned to Flight PRO101 for radar vectoring for an approach on Runway 24R at St-Hubert Airport. Interception of the approach centreline was estimated at 9 miles on final. The controller also asked Flight PRO101 to acknowledge, which was done by pressing the transponder's IDENT button. The crew attempted without success to communicate with ATC with its second radio. The terminal controller continued to guide the aircraft, and the acknowledgement was given via the IDENT button. The final transmission received by the crew was the instruction to switch to the other terminal frequency. The terminal controller coordinated the arrival of Flight PRO101 with the St-Hubert tower controller. At the request of the tower controller, the aircraft was authorized for an approach and landing on Runway 24R. This transmission was not received by the crew.

During radar vectoring, the crew was able to estimate its position in relation to the St-Hubert Airport (see Figure 1). The pilot-in-command remembered that, during the initial climb in Montréal, he could see the ground through a thin scattered layer of cloud, to an altitude of about 2000 feet. The crew then decided to leave the last assigned altitude of 3000 feet for the minimum sector altitude (MSA),[2] which he believed to be 2200 feet. The MSA to the west of the Hauts-Bois non-directional beacon (NDB) (see Appendix A), the final approach fix (FAF) for Runway 24R, is 2200 feet while the MSA to the east of the Hauts-Bois NDB is 2600 feet.

At 2200 feet, the pilot-in-command saw the ground and made a steep turn to the left while maintaining visual reference. Once the aircraft was levelled, the crew estimated the ceiling to be approximately 200 feet above ground level (agl) and the visibility to be ½ mile. The radar track shows that, during the descent, the aircraft was 9 nautical miles (nm) east-northeast of the NDB; the MSA for this area would have been 2600 feet.

---

[2] MSA: The lowest altitude that will provide a minimum clearance of 1000 feet above all objects located in an area contained within a sector of a circle of 25 nm radius centred on a radio aid to navigation.

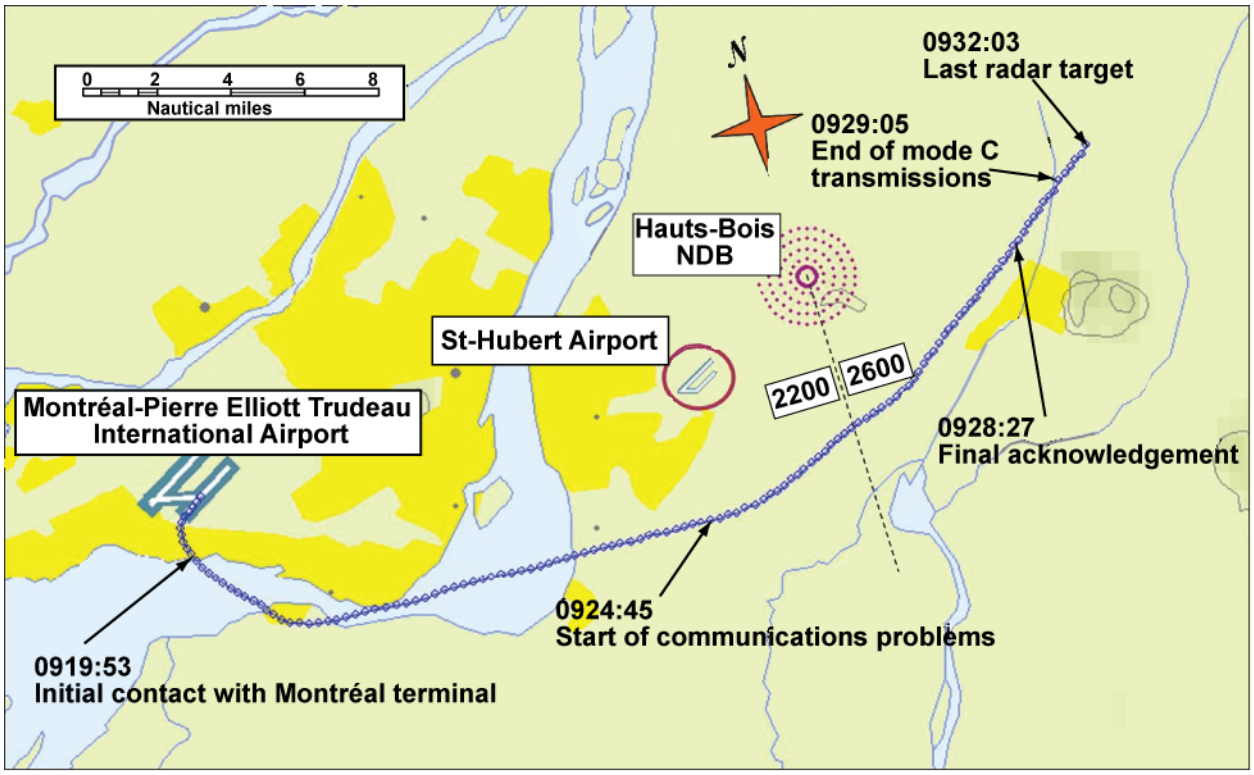

Figure 1. Radar track

The crew proceeded toward the St-Hubert Airport on an estimated heading without actually having the airport in sight. In preparation for landing, the crew pulled the landing gear circuit breaker switch in accordance with the landing gear emergency extension procedure, and the landing gear was extended manually. The global positioning system (GPS) started operating again, and the copilot quickly selected the direct route to St-Hubert. The GPS displayed a distance of 12 nm and a heading of 255° to proceed to St-Hubert. At approximately 5 nm from the Runway 24R threshold, the three green lights indicating that the landing gear was down and locked illuminated. The copilot delivered an emergency landing briefing to the passengers, and the pre-landing checklist was completed. Flight PRO101 landed safely at 0945 and taxied to the ramp. On landing at St-Hubert, the ceiling was 700 feet agl and visibility was 3½ statute miles (sm). The duration of the flight was 27 minutes.

The annunciator panel centered on the upper section of the instrument panel includes several red warning lights associated with the aircraft's systems that illuminate in the event of an anomaly. Illumination of a warning light simultaneously lights the main warning light located to the left of the panel, almost directly in front of the left-seat pilot. When activated, this warning light flashes until it is deactivated. The purpose of the main warning light is to attract the crew's attention to the annunciator panel to identify the system that failed so the crew can apply the appropriate procedure. In this occurrence, the two white auto-ignition lights were on, which is normal, until the engine power control levers are moved beyond a predetermined power (torque) that disengages the auto-ignition system. The checklist states that, if the warning lights remain on when the levers are moved beyond the predetermined power point, the position of the engine start switches must be checked.

Engine auto-ignition switches and ignition and engine start switches on the King Air 100 aircraft are located on the lower left of the instrument panel (see Photo 1). They are accessible to the pilot-in-command only, and are not visible to the copilot. The view of the switches is obstructed by the left control wheel and any documents affixed to it. A movement of the head is required to observe the switches.

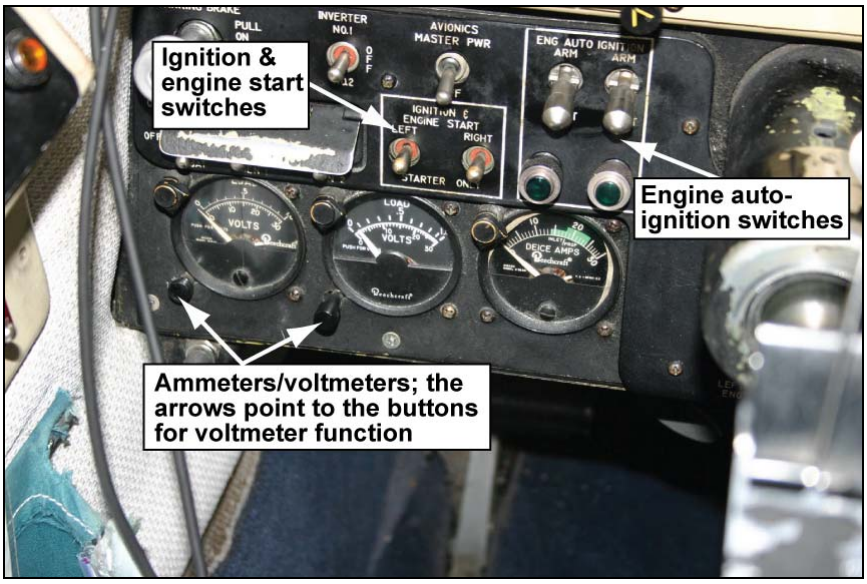

Photo 1. The switches

The auto-ignition switches have two positions: up and down. When the switches are in the down position, the system is deactivated. When the switches are in the up position, the auto-ignition is in the armed mode. The position is confirmed by two green warning lights located below the switches. In addition, two white warning lights, "L IGNITION" and "R IGNITION," on the annunciator panel illuminate when the engine torque falls below 425 pound-feet. The switches are protected against inadvertent activation by a detent that requires the switch lever to be pulled to make a selection. The King Air A100 checklist requires that the switches be placed in the armed mode during the line-up checks, which is the final item to be completed before take-off. They must be placed in the OFF position during the post-landing check.

The ignition and engine start switches have three positions. The down position is used to turn the engines without ignition. The centre position disables the switches, and the up position is for ignition and engine start. There is no protective detent on these switches; therefore, they can be activated inadvertently. In the down position, a return spring moves the switch toward the centre. However, when the switch is placed in the up position for engine start-up, there is no return spring. The switch thus remains in the ignition and engine start position until it is deactivated. In this position, the appropriate white warning light, "L IGNITION" or "R IGNITION," on the annunciator panel illuminates and remains on, regardless of the engine power produced.

On King Air 100 engines, the same unit alternates the functions of starter and generator. Selecting the ignition and engine start position activates the starter function and deactivates the generator function. In such a case, the battery provides all of the aircraft's electrical needs. On C-GJLP, if the switches are inadvertently left in the ignition and engine start position, the crew is not provided with the red light warnings "L GENERATOR" and "R GENERATOR" that would indicate that the two generators are off line.

The only indication available to the crew would have been a loadmeter reading. The loadmeters would have indicated zero and the voltmeter selection would have indicated the voltage remaining in the battery (24 volts or less) instead of the 28 volts produced by the generators.

The line-up checklist does not require a verification of the load indicators when the auto-ignition switches are placed in the ON position. The load indicators located under the ignition and engine start switches are not easy to read by the pilot in the left seat and are not visible to the pilot in the right seat.

The initial problem observed by the crew was the indication that the gear was in transit. The "abnormal gear indication" checklist indicates that the landing gear is to be recycled. This action is known to rectify a microswitch[3] problem. However, if the situation persists, the crew must leave the lever in the up position, reduce the speed to Vle[4] and review the flight planning. The instruction calling for the gear to be recycled does not take into account an electrical problem and does not refer the pilot to the applicable "landing gear will not retract" checklist. This checklist instructs the pilot to pull the circuit breaker switch to put the landing gear motor off line. Because this procedure was not performed, the landing gear motor remained on, which exacerbated the rate of battery discharge.

The aircraft GPS can operate on a voltage range of 11 to 32 volts. The loss of the GPS confirms that the voltage of the battery had decreased below 11 volts. When the crew pulled the landing gear circuit breaker switch to extend the landing gear manually, the reduction in electrical demand allowed the battery voltage to rise back up and to reactivate the GPS. A few hours after the occurrence, the battery voltage reading was 18 volts. Communication and navigation radios normally require a voltage of over 20 volts. The voltage was also insufficient to power the inverters, which provide alternating current to the flight instruments.

The occurrence aircraft, serial number B 148, was built in 1973 and was maintained in accordance with existing regulations. Following the occurrence, retraction tests revealed that the landing gear operated properly. The retraction problem was related to the decrease in voltage, which lowered the capacity of the landing gear's electric motor to below the torque required to retract the main wheels, which retract toward the front of the aircraft against the relative wind.

During the investigation, the TSB tested the C-GJLP annunciator panel warning lights. These tests confirmed that the generator "GEN" warning light does not illuminate if the crew improperly positions the ignition and engine start switch; therefore, the crew cannot receive a critical warning. However, the same test conducted on another King Air 100, serial number B 235, immediately illuminated the generator warning lights and activated the main warning light.

The manufacturer confirmed that, starting with serial number B 224, the voltage regulator of each generator was replaced by an electronic model. Changes in the electrical wiring required for the modification allowed activation of the generator warning lights in the event that the ignition and engine start switches were selected inadvertently. This modification was not offered to convert electrical systems of earlier King Air models.

---

3 Microswitch: small switch confirming the position of the landing gear

4 Vle: landing gear extended speed

The momentary illumination of the main warning light encountered by the crew during the line-up checks on the runway could not be duplicated during the tests. This type of erratic indication had been observed on C-GJLP when it was kept outside during cold and damp weather, as was the case on the morning of the incident.

Two other similar occurrences occurred in the past within the company. In the first case, the anomaly was noted before take-off; in the second case, the night VFR aircraft was able to come back and land without incident. These two occurrences were not documented and only existed in the company's corporate memory. Transport Canada implemented safety management systems (SMS).[5] However, the implementation of the SMS applicable to operators whose air operator certificate was issued under Part VII, Subpart 3 of the CARs is expected to come into force around September 2008. Once implemented, the SMS will require, in such a case, a review of the circumstances and a follow-up with the crews.

A review of the TSB database revealed only one similar occurrence (A04W0047) of a total loss of electrical power on a King Air 100 during which the crew had inadvertently placed the engine start switches in the ignition and engine start position. Since these occurrences do not necessarily result in an emergency or in damage to the aircraft, it is not mandatory to report them to the TSB. Therefore, available statistics probably do not reflect reality.

The CARs (Section 602.137), the *Canada Air Pilot* and the *Canada Flight Supplement* specify the procedures for a two-way radio communication failure in IFR or VFR flight. However, these procedures do not take into account a total loss of radio navigation systems. In such a case, pilots are expected to exercise good judgment in whatever action they choose to take. The procedures allow the use of a cellular telephone in the event of a total failure. It was only after the occurrence flight that it was realized that this option would have been available because there were cellular telephones on board the aircraft.

Analysis

All indications suggest that, shortly before take-off, the pilot-in-command selected the ignition and engine start switches instead of the auto-ignition switches. Although the two sets of switches have distinct operating mechanisms, the differences were not sufficient to prevent the error. This type of error is common for routine tasks where the object to be activated is located close to another. The line-up checklist does not require a load indicator reading when the auto-ignition switches are selected, which would confirm that the generators are on line.

Starting with serial number B 224, the generator warning lights on the King Air 100 illuminate when they are off line due to switches left in the ignition and engine start position. However, this modification was not offered to operators of earlier King Air models. Even though the

---

[5] SMS: A documented process for managing risks that integrates operations and technical systems with the management of financial and human resources to ensure aviation safety or the safety of the public.

ignition and engine start switches are equipped with a return spring in the position used to turn the engine without ignition, this option was not used for the start position. Therefore, the switches remain in the start position if they are inadvertently placed in this position, until they are returned manually.

Emergency procedures are formulated to provide crews with practical solutions to abnormal situations. In order for crew members to be able to follow an emergency procedure, they must recognize the situation, identify the appropriate solution and apply it. Without any clear indication that the generators were off line, the crew did not identify that the source of all of the failures was the lack of electric power, for which a procedure exists. A specific check of the white auto-ignition warning lights that remained illuminated would have led the crew to the ignition and engine start switches. However, since these white warning lights are primarily used to indicate that the system is on, they do not suggest that there is an anomaly that needs to be addressed on a priority basis. This would explain why the crew did not complete the applicable checklist and instead focused on other developing anomalies.

The logic of recycling the landing gear following the illumination of the in-transit warning light does not take into account the possibility of an electrical failure. The final item indicating that the flight planning must be amended gives the impression that there are no other procedures available to rectify the situation and does not refer the flight crew to the "landing gear will not retract" checklist. If the crew would have completed this checklist, the electrical power could have been cut to the landing gear motor, and the energy saved would have kept the radios and flight instruments operational for several minutes. The GPS would have remained operational, and several options would then have been available. Because fuel endurance was sufficient, the flight could have been diverted to a location where conditions were more favourable for VFR flight.

The series of anomalies overlapping immediately after take-off focused the crew's attention and compelled the crew to continuously reassess the new failures:

- the landing gear remained in transit when the lever was placed in the up position;
- the auto-ignition warning lights remained on;
- some flight instruments failed;
- radio communication instruments failed;
- radio navigation instruments failed; and
- the GPS failed.

The crew did not identify the source of the problems as being an electrical failure. In IFR conditions, the crew encountered flight instrument and navigation system failures that are not provided for in the regulations applicable to the loss of two-way communications. Not knowing the source of the problem and apprehending new failures, the crew decided to initiate a descent to regain visual contact with the ground. The decision to descend to 2200 feet was based on the fact that the crew members were familiar with the area and that the radar vectors received before the communication failure provided them with an approximate position. In addition, they had just left the Montréal/Pierre Elliott Trudeau International Airport where they were able to keep visual contact with the ground until reaching an altitude of 2000 feet.

Gathering and analyzing information related to operational experiences is essential to efficiently manage safety. Incidents that seem minor provide an opportunity to understand when and where errors could occur and help in formulating corrective action to eliminate them. Once in place, the SMS will motivate operators to analyze this type of incident. The lack of disclosure of this information allowed the same situation to recur under more difficult conditions. Without a formal process to analyze operational experiences, it is likely that the same errors will recur.

Findings as to Causes and Contributing Factors

1. Shortly before take-off, the pilot-in-command inadvertently selected the ignition and engine start switches instead of the auto-ignition switches. As a result, all of the aircraft electrical needs were powered by the battery, which was unable to maintain the load needed for the normal use of the electrical system and its related instruments.

2. The line-up checklist does not require a load indicator reading when the auto-ignition switches are selected, which would confirm that the generators are on line.

3. The absence of a clear indication by the warning lights that the generators were off line precluded the crew from the information needed to quickly recognize the anomaly.

4. The crew completed the "abnormal gear indication – in transit" checklist. This checklist gives the impression that no other procedures are available to rectify the situation and does not refer the flight crew to the "landing gear will not retract" checklist.

5. The crew did not complete the "landing gear will not retract" checklist; if it would have done so, the electrical power could have been cut to the landing gear motor. The energy saved would have kept the radios and flight instruments operational for several minutes.

Finding as to Risk

1. The crew descended to an altitude below the sector altitude applicable to its position, without knowing its exact position. This situation increased the risk of collision with the terrain or with obstacles.

Other Findings

1. The absence of a formal process for analyzing operational experiences and the lack of disclosure of information on previous similar accidents or incidents allowed the same situation to recur under more difficult conditions.

2. The crew encountered overlapping failures, and it did not have the time to complete the checklists specific to each failure, which, eventually, would have helped rectify the situation. Instead, the crew decided to descend to regain and maintain visual contact with the ground.

Safety Action

Since this incident, during initial and recurrent ground training, Propair Inc. instructors emphasize the risk associated with the starter/generator system and its consequences on some of the company's Beechcraft King Air 100.

This report concludes the Transportation Safety Board's investigation into this occurrence. Consequently, the Board authorized the release of this report on 13 February 2008.

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

Appendix A – Instrument Landing System Approach Instructions – Runway 24R at Montréal/St-Hubert Airport