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

AVIATION OCCURRENCE REPORT

LOSS OF CONTROL DURING CLIMB

LES AILES DE CHARLEVOIX INC.
CESSNA 421C GOLDEN EAGLE C-GVPB
CHARLEVOIX, QUEBEC 2 km SE
03 AUGUST 1994

REPORT NUMBER A94Q0140

Canada

MANDATE OF THE TSB

The Canadian Transportation Accident Investigation and Safety Board Act provides the legal framework governing the TSB's activities. Basically, the TSB has a mandate to advance safety in the marine, pipeline, rail, and aviation modes of transportation by:

- conducting independent investigations and, if necessary, public inquiries into transportation occurrences in order to make findings as to their causes and contributing factors;
- reporting publicly on its investigations and public inquiries and on the related findings;
- identifying safety deficiencies as evidenced by transportation occurrences;
- making recommendations designed to eliminate or reduce any such safety deficiencies; and
- conducting special studies and special investigations on transportation safety matters.

It is not the function of the Board to assign fault or determine civil or criminal liability. However, the Board must not refrain from fully reporting on the causes and contributing factors merely because fault or liability might be inferred from the Board's findings.

INDEPENDENCE

To enable the public to have confidence in the transportation accident investigation process, it is essential that the investigating agency be, and be seen to be, independent and free from any conflicts of interest when it investigates accidents, identifies safety deficiencies, and makes safety recommendations. Independence is a key feature of the TSB. The Board reports to Parliament through the President of the Queen's Privy Council for Canada and is separate from other government agencies and departments. Its independence enables it to be fully objective in arriving at its conclusions and recommendations.

Transportation Safety Board of Canada

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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 Occurrence Report

Loss of Control During Climb

Les Ailes de Charlevoix inc.
Cessna 421C Golden Eagle C-GVPB
Charlevoix, Quebec 2 km SE
03 August 1994

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Synopsis

The aircraft took off from runway 15 of Charlevoix Airport, Quebec, on a flight to Trois-Rivières, Quebec, with the pilot and five passengers on board. Shortly after take-off, witnesses saw greyish smoke emanating from the left engine. The aircraft turned left, continued on its heading momentarily, then banked left and nosed down. The aircraft crashed on the ground and was destroyed by the impact and post-crash fire. The six occupants died instantly.

The Board determined that it is probable that a loss of oil pressure in the left engine caused a loss of power just after take-off. The pilot was unable to maintain the minimum control speed (V_{MC}) of the aircraft.

Ce rapport est également disponible en français.

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1.0 Factual Information

1.1 History of the Flight

Around 1950 eastern daylight saving time (EDT)[1], the Cessna 421C aircraft, registration C-GVPB, operated by les Ailes de Charlevoix inc., took off on a visual flight rules (VFR)[2] charter flight from Charlevoix Airport, Quebec, to Trois-Rivières, Quebec, with one pilot and five passengers on board. Shortly after take-off, witnesses saw greyish smoke emanating from the left engine. The aircraft entered a steep left turn followed by a descent. It then continued in the new direction. Shortly after, the aircraft yawed and entered an uncontrolled roll, nosed down, and crashed. The aircraft caught fire on impact. All six occupants were fatally injured during the impact. The aircraft was destroyed.

The accident occurred in daylight, 1.14 nautical miles (nm) southeast of the end of runway 15, at latitude 47°35'45"N and longitude 070°11'37"W.

1.2 Injuries to Persons

	Crew	Passengers	Others	Total
Fatal	1	5	-	6
Serious	-	-	-	-
Minor/None	-	-	-	-
Total	1	5	-	6

1.3 Damage to Aircraft

The aircraft was destroyed by impact forces and the post-impact fire.

1.4 Other Damage

None.

1.5 Personnel Information

	Pilot-in-Command
Age	37
Pilot Licence	Commercial

1 All times are EDT (Coordinated Universal Time minus four hours) unless otherwise stated.

2 See Glossary for all abbreviations and acronyms.

	Pilot-in-Command
Medical Expiry Date	01 May 1995
Total Flying Hours	5,261
Hours on Type	1,215
Hours Last 90 Days	47
Hours on Type Last 90 Days	47
Hours on Duty Prior to Occurrence	5
Hours Off Duty Prior to Work Period	18

The pilot was certified and qualified for the flight in accordance with existing regulations. The pilot had supervised the importation of the aircraft in August 1989 and had flown it since then.

At the beginning of June 1994, the pilot received flight training to prepare for the renewal of his pilot qualifications. He took his flight test with Transport Canada in early June and his proficiency certificate (PPC) was renewed to 01 July 1995.

1.6 Aircraft Information

Manufacturer	Cessna
Type	421C
Year of Manufacture	1978
Serial Number	421C-0484
Certificate of Airworthiness (Flight Permit)	16 November 1990
Total Airframe Time	3,190 hr
Engine Type (number of)	Teledyne Continental GTSIO-520-L (2)

Propeller/Rotor Type (number of)	McCauley (3)
Maximum Allowable Take-off Weight	7,560 lb
Recommended Fuel Type	Avgas 100 LL
Fuel Type Used	Avgas 100 LL

The weight and balance of the aircraft were within the prescribed limits. The aircraft weight was estimated at 7,450 pounds, which is below the maximum allowable take-off weight.

1.7 *Meteorological Information*

For a limited period during the day, an observer certified by Environment Canada makes weather observations at Charlevoix Airport. The last regular observation was made at 1600 EDT, four hours before the accident. The hourly weather observation indicated a layer of broken cloud at 2,000 feet, another at 10,000 feet, and a third at 20,000 feet. The temperature was 17 degrees Celsius and the winds were from the southeast at nine knots.

At Quebec City Airport, 80 nautical miles (nm) SW of Charlevoix, the regular observation at 2000 EDT reported a broken layer at 2,500 feet and a thin broken layer at 25,000 feet. The temperature was 19 degrees Celsius and the winds were light.

1.8 *Communications*

Shortly after landing at Charlevoix, the pilot contacted the Quebec City Flight Service Station (FSS) to close his VFR flight plan from Havre-Saint-Pierre. No ground station received any radio messages from the aircraft at the time of take-off.

1.9 *Aerodrome Information*

Charlevoix Airport runway 15 is 4,500 feet long and has a downward slope of 0.6 percent; the difference in elevation between the two thresholds is 26 feet. The Charlevoix runway centre line runs at a 90-degree angle to the St. Lawrence River, which is 1.1 nm from the departure end of runway 15. The reference point elevation of the Charlevoix aerodrome is 977 feet above sea level (asl). When the winds are calm, pilots prefer to take off towards the St. Lawrence or to approach for a landing from over the St. Lawrence because there are no obstacles on the runway axis.

The aircraft was found 1.14 nm from the departure end of runway 15 on a heading of 118 degrees magnetic. The terrain elevation at that point is 400 feet asl (see Appendix A).

1.10 *Flight Recorders*

The aircraft was not equipped with a flight data recorder (FDR) or a cockpit voice recorder (CVR), nor was either required by regulation on this type of aircraft.

1.11 *Wreckage and Impact Information*

The aircraft crashed on a heading of 090 degrees magnetic, on a descent angle of 60 degrees and with a left bank angle of 44 degrees. The fuselage continued on its trajectory and came to rest on a heading of 230 degrees magnetic, 118 feet from the point of initial impact. The fuselage carried with it the empennage and the right engine.

The left wing of the aircraft, from the wing-tip to the fuselage attachment point, failed in the initial impact and came to rest at the beginning of the impact sequence. The right wing, from the wing-tip to the engine attachment point, was to the right of the impact trajectory and 100 feet from the point of initial impact.

The landing gear was down and locked. The flaps were retracted. The aileron and rudder trim tabs were found in the normal positions for take-off, but the elevator trim tab was not. It was found separated and at a 20° tab-down position. Because of the breakup of the aircraft and the tab, the position of the elevator trim tab as found was not considered as its position prior to the crash.

1.11.1 Metallurgical Analysis

A metallurgical analysis of the exhaust stacks was conducted at the TSB Engineering Branch Laboratory. Previous analyses have shown that this metal exhibits different characteristics when crushed at different temperatures. In the Cessna 421, the left engine exhaust system was colder than that of the right engine, indicating that the left engine was not functioning normally.

1.11.2 Flight Instruments Analysis

An analysis of the following flight instruments was conducted by the TSB Engineering Branch Laboratory: airspeed indicator, vertical speed indicator, encoding altimeter, dual tachometer, fuel flow indicator, horizon gyro, and turn and slip indicator.

Except for the turn and slip indicator, whose mechanism indicated a rate of turn clearly exceeding three degrees per second, these instruments did not provide any reliable information.

1.11.3 Emergency Locator Transmitter

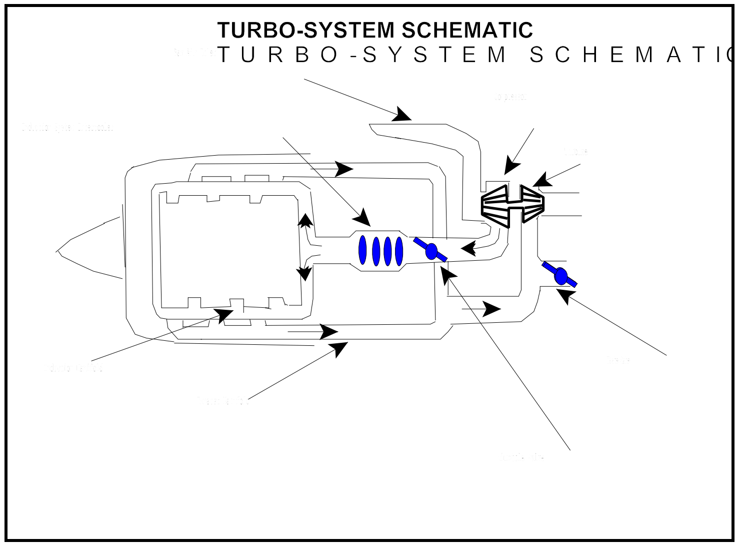
No signals were transmitted by the emergency locator transmitter (ELT) at the time of impact. The ELT was mounted in the rear fuselage of the aircraft. The antenna lead was severed and the housing collapsed on impact. Analysis by the TSB Engineering Branch Laboratory revealed that the deformation of the housing caused the nine-wire ribbon cable to become disconnected from the printed circuit, cutting off power from the batteries. When the ribbon cable was reconnected at the TSB Engineering Branch Laboratory, the ELT transmitted an acceptable signal.

1.11.4 Engine Analysis

The two engines were examined at the TSB Engineering Branch Laboratory. All observed engine damage was attributable to the impact and/or fire. Teardown of the engines revealed no pre-impact internal condition that could have affected their capacity to produce power. There were no signs of insufficient lubrication on the crankshaft bearings. No information regarding the level of power produced by the engines at the time of impact could be established from the analysis of the engine components.

1.11.5 Supercharger Analysis

Each engine is supercharged by a supercharger driven by exhaust gases. A waste gate controls the amount of exhaust gases directed to the supercharger, and this regulates boost. Waste gate movement is controlled by oil pressure, which acts against a spring to close the waste gate and increase supercharger rpm, depending on throttle position and engine parameters. The supercharger increases engine power by 27 per cent.



Rubberized hoses conduct oil to the waste gate and lubricate the supercharger. The hoses are located close to the exhaust system, and they were replaced in July 1993. Although they were encased in a fireproof jacket, the hoses on the left engine were destroyed in the fire.

Impact forces completely broke up the left supercharger and tore off the waste gate; the right supercharger, which remained attached to the wing, was relatively intact. The left waste gate was stuck in the open position and the supercharger showed no signs of rotation. The right waste gate was stuck in the closed position, and the supercharger exhibited obvious signs of rotation.

1.11.6 Propellers

Prior to ground impact, the left engine propeller struck a seven-inch diameter tree 15 feet above the ground, carving a notch one inch deep. Correlation of the angle of impact of the propeller on the tree with the descent angle of the aircraft indicates that the left engine propeller was feathered at the time of impact.

The TSB Engineering Branch Laboratory examined the two propellers. It was determined that neither propeller had been damaged prior to impact.

Propeller blade pitch is controlled by engine oil pressure exerting force against a return spring that tries to feather the propeller. Oil pressure is augmented and modulated by a propeller governor controlled by the position of the propeller pitch lever in the cockpit. Loss of engine oil pressure will eventually starve the propeller governor pump of oil. Consequently, lack of engine oil pressure will automatically cause feathering of the propeller.

1.11.7 Fuel

No samples were recovered from the wreckage. A fuel sample was taken from the company fuel reservoirs. Analysis of this sample revealed that it exhibited characteristics typical of aviation gasoline and was the correct fuel for the engines.

1.12 Medical Information

There was no evidence that incapacitation or physiological factors affected the pilot's performance. Toxicological test results were negative.

1.13 Fire

A fire broke out on impact. The left wing-tip struck the ground first and the tank ruptured. The ensuing fire covered an area 65 feet long by 20 feet wide. The fire was confined to the left side of the impact trajectory.

A separate fire of less significance occurred at the right wing 100 feet from the point of initial impact. The wing was inverted on the ground and was completely destroyed. The fuel-fed fire remained near the wing and did not spread.

An intense fire occurred in the fuselage. It completely destroyed the interior of the fuselage. The aluminum skin was completely melted on the top of the fuselage and on the sides of the aircraft.

The elevator and vertical stabilizer were found on the ground outside the fuselage fire zone and were not damaged by fire.

1.14 Survival Aspects

The damage caused to the aircraft at the time of impact indicates that the aircraft struck the ground at high speed. Because of the high deceleration forces, the accident was considered to be non-survivable.

1.15 Performance Parameters

A graph in the *Pilot's Operating Handbook* indicates that the rate of climb of the aircraft on one engine at the maximum allowable take-off weight as estimated is 278 feet per minute (fpm). To obtain this rate of climb, the pilot must maintain an indicated airspeed (IAS) of 111 knots.

Rate of climb is affected by several factors. The drag caused by the extended landing gear reduces the climb rate by 350 fpm. If the propeller is not feathered, the climb rate is reduced further by another 400 fpm.

At the time of impact, the propeller was feathered and the landing gear was down. In this configuration, the aircraft could not climb.

1.16 Minimum Control Speed

1.16.1 Definition

The manufacturer defines the minimum control speed (V_{MC}) as the minimum speed at which the aircraft is controllable with one engine not producing power, the other engine producing full power, and the aircraft banked five degrees to the side of the engine producing power. For this aircraft, the V_{MC} is 80 knots IAS. The critical engine on this type of aircraft, the Cessna 421, is the left engine.

1.16.2 Loss of Control

When an engine fails, the first movement to appear is that of the aircraft yawing. The magnitude of the yaw is a function of the aircraft's speed, the difference between the thrust produced by the two engines, the moment arm of the thrust vector, the moment arm between the centre of gravity and the rudder, and the resistance on the side of the engine producing less power.

If the yaw movement is not counteracted, a roll will develop. This will raise the engine producing more power above the level of the other engine, and thrust will cause the aircraft to pitch down; a descent in a pronounced dive will result. The process occurs rapidly, and loss of control can be sudden.

1.17 Additional Information

Another Cessna 421 experienced a power loss in the left engine shortly after this accident. Witnesses saw greyish smoke coming from the left engine. The pilot of that aircraft noticed that the engine oil pressure was zero, and he felt severe vibrations from the engine when he shut it down and feathered the propeller.

This aircraft was equipped with an optional system consisting of an accumulator containing a pressure reserve in order to return the propeller to a lower pitch as required. Examination on the ground revealed that the flexible hose between the accumulator and propeller governor had ruptured after touching the exhaust stack, and the casing was completely drained of oil. The hose was encased in a fireproof jacket. This was the first flight by the aircraft since the optional system was installed. The aircraft was in flight for one hour when the heat of the exhaust system overcame the combined resistance of the jacket and hose.

The vibrations produced by the propeller, when the blade angle started to increase towards the feathered position because of a lack of oil, maintained the impression that the engine had failed.

Greyish smoke issuing from an engine is normally caused by a major oil leak spraying on the exhaust stacks.

2.0 Analysis

2.1 Introduction

Fire damage to the engines deprived the investigation of some evidence that could have been related to the causes of a power loss in the left engine. Consequently, the analysis will focus on the relationship between the different pieces of evidence found and of their effect on the flight.

2.2 Greyish Smoke

The greyish smoke that the witnesses at the runway end saw coming from the left engine may have been caused by oil from a ruptured hose or other major leak spraying on the exhaust stacks. All oil lines in this engine type are internal, except those in the supercharging system. The engine oil pressure pushing against a spring closes the exhaust gas waste gate and impels the supercharger. If one of the supercharger lines had failed, the oil on the engine exhaust system would have produced greyish smoke and the supercharger would have ceased to function because the spring would have closed the waste gate. In addition, it is unlikely that the engine would have been damaged by a lack of lubrication because of the short elapsed time between the appearance of the smoke and the impact.

2.3 Engines

On teardown of the left engine, no anomalies were observed that could have prevented the engine from functioning normally. The left supercharger blades were not damaged and the left waste gate was open, suggesting that the supercharger was capable of turning but was not turning at the time of impact. Also, impact marks made by the left propeller on a tree show that the propeller was feathered and the engine was not producing power. These observations were corroborated by the exhaust system analysis.

2.4 Yaw Movement

The left turn observed by the witnesses must have been initiated by the yaw caused by the asymmetrical thrust of the engines. The difference between the thrust levels was significant, as the pilot did not appear to have counteracted them quickly. After regaining control of the aircraft, he continued on a descent path.

To obtain a rate of climb at the maximum allowable weight, the pilot must retract the landing gear and quickly feather the propeller, among other things. It could not be determined whether the landing gear was retracted after take-off and subsequently lowered. Also, it could not be determined whether the propeller was feathered by pilot input or because of a loss of oil pressure. However, it seems clear that one of these actions or perhaps both were not executed rapidly, as the aircraft continued to descend after the smoke appeared.

3.0 Conclusions

3.1 Findings

1. On teardown of the engines, no anomalies were observed that could have affected the engines prior to the impact.

2. The left engine supercharger was not functioning at the time of impact.

3. The left engine propeller was feathered at the time of initial impact.

4. One of the oil lines in the supercharging system probably ruptured, causing a loss of oil pressure in the engine.

5. Greyish smoke emanating from an engine is normally caused by a major oil leak spraying on the exhaust stacks.

6. The left turn by the aircraft was initiated by the asymmetrical thrust of the engines.

7. The evidence gathered is consistent with a loss of control of the aircraft below V_{MC}.

8. The pilot did not maintain speed above V_{MC}.

3.2 Causes

It is probable that a loss of oil pressure in the left engine caused a loss of power just after take-off. The pilot was unable to maintain the minimum control speed (V_{MC}) of the aircraft.

4.0 Safety Action

The Board has no aviation safety recommendations to issue at this time.

This report concludes the Transportation Safety Board's investigation into this occurrence. Consequently, the Board, consisting of Chairperson John W. Stants, and members Zita Brunet and Hugh MacNeil, authorized the release of this report on 21 August 1995.

Appendix A - Flight Path

Appendix B - List of Supporting Reports

The following TSB Engineering Branch Laboratory reports were completed:

LP 117/94 - Exhaust Analysis Temperature Determination;

LP 121/94 - Engine & Propeller Exam (fuel sample analysis also included); and

LP 127/94 - ELT & Instruments Examination.

These reports are available upon request from the Transportation Safety Board of Canada.

Appendix C - Glossary

asl	above sea level
CVR	cockpit voice recorder
EDT	eastern daylight saving time
ELT	emergency locator transmitter
FDR	flight data recorder
fpm	feet per minute
FSS	Flight Service Station
hr	hour(s)
IAS	indicated airspeed
km	kilometre(s)
lb	pound(s)
N	North
nm	nautical mile(s)
PPC	pilot proficiency certificate
TSB	Transportation Safety Board of Canada
VFR	visual flight rules
V_{MC}	minimum control speed
W	West
°	degree(s)
'	minute(s)
"	second (s)

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